COMPARISON OF THREE INSECT CONTROL SCHEMES ON POPULATIONS OF COTTON INSECTS AND SPIDERS, FRUITING CHARACTERISTICS, FRUIT DAMAGE AND YIELD OF COTTON

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TABLE OF CONTENTS

LIST OF TABLES

Table		Page

Table		Page

LIST OF FIGURES

Figure | Page

CHAPTER I

INTRODUCTION

J.C. Neal, writing in 1892 (p. 4) in reference to *Heliothis armigera* (Hbn.), now *H. zea* (Boddie), said "If Oklahoma ever unfortunately becomes a 'Cotton State' this worm...will make the planter's life very weary indeed." Oklahoma did become somewhat of a 'Cotton State,' ranking ninth in cotton lint production among all states in 1973. Cotton was surpassed in acreage only by wheat and sorghum and in cash receipts only by wheat as major crops of the state that year (Oklahoma Crop and Livestock Reporting Service, 1974).

Until about 1950, *H. zea*, the cotton bollworm, was not especially important as a cotton pest in Oklahoma. Rather, the boll weevil, *Anthonomus grandis* Boheman, which invaded the United States the same year Neal made his prediction regarding *Heliothis*, was considered the overwhelmingly dominant insect pest of Oklahoma cotton (Bryan, 1961). From about 1950 until the present time, the *Heliothis* complex, composed of the bollworm and the tobacco budworm, *H. virescens* F., has been doing much to "make the planter's life very weary indeed." The bollworm was described by Coppock in 1971 as the most damaging pest to Oklahoma cotton. Today the tobacco budworm is rapidly becoming the most destructive pest in the entire Cotton Belt (Roussel, 1976).

Efforts to control the *Heliothis* complex and other cotton pests in Oklahoma, as elsewhere, have largely depended upon the use of chemical insecticides. However, problems concommitant with heavy insecticide usage, especially the increasing resistance of the Heliothis complex and the boll weevil, coupled with the high priority now placed on environmental quality, make the development of alternatives to total reliance on chemical control a matter of great urgency.

One alternative approach which has received attention recently is the establishment of more diversified habitats which serve to promote large populations of natural enemies of cotton pests and thus increase the level of biological control exerted upon these pests. This study involved such an approach. Its primary objective was to compare predator populations and pest control achieved by interplanting cotton and grain sorghum with those obtained by following recommended insecticide treatment procedures and those which resulted when no type of control was instituted. The three schemes were compared on the bases of populations of predatory arthropods and of the cotton fleahopper, Pseudatomoscelis seriatus (Reuter), fruit damage by Heliothis spp. and by the boll weevil, fruiting characteristics and yield.

CHAPTER II

REVIEW OF THE LITERATURE

A Short History of the Cotton Pest Problem

Prior to the invasion of the boll weevil in 1892, arthropod pests did relatively little damage to cotton in the United States. Occasional outbreaks of the bollworm, the cotton leafworm, *Alabama argillacea* (Hubner), and the cotton aphid, *Aphis gossypii* Glover, occurred but there were no perennially occurring dominant pests.

The boll weevil invaded the United States from Mexico, entering around Brownsville, Texas. It caused serious damage to Texas cotton and rapidly spread throughout Louisiana, Arkansas, Mississippi and the rest of the cotton producing areas of the southeastern United States.

The importance of cultural measures in weevil control, especially the early fall destruction of old cotton in the field, was stressed soon after the insect entered the country (Howard, 1897; Hinds, 1908; Knapp, 1910). Experiments with a number of different chemicals were conducted in an intensive search for an insecticide effective against the pest. In 1918, Coad reported that calcium arsenate was effective for boll weevil control. Soon this chemical was in widespread use. Simultaneously with this use, the cotton aphid rose to the status of a serious pest in some cotton growing areas. The relationship between the rise of the aphid and use of arsenate was noted as early as 1928 by Folsom, who also noticed an increase in bollworms in calcium arsenate dusted fields.

Smith and Fontenot (1942) reported aphid populations three times as large in fields dusted with arsenicals as in those not dusted. They also reported fewer coccinellids and chrysopids in the dusted areas. Ewing and Ivy (1943) reported increases in bollworm infestations associated with aphid increases when calcium arsenate dosages were light or poorly timed.

In the late 1940's cotton insect control largely changed from arsenicals and nicotine compounds to the chlorinated hydrocarbons. Such compounds as BHC, chlordane, aldrin, dieldrin and heptachlor were used for boll weevil control; for Heliothis control it was necessary to add DDT. As little as 0.5 pound per acre was effective for bollworm control when in combination with one of the weevil control chemicals (Harris et al., 1972).

The chlorinated hydrocarbons were even more destructive to predators and parasites than the arsenicals had been. Several accounts of the adverse effects on populations of beneficials were reported, but were given relatively little attention. The new synthetic insecticides were widely regarded as essentially the panacea to insect pest problems; the potential dangers were, for the most part, ignored in the enthusiasm about the new chemicals. Newsom and Smith (1949) considered the chlorinated hydrocarbons worse than the arsenicals on predators of the genera Geocoris and Orius, but no worse on the Coccinellidae--both calcium arsenate and the newer products were highly destructive to that family. Heavy infestations of spider mites and injurious bollworm infestations from relatively few eggs were also reported by Newsom and Smith. Other studies indicting the chlorinated hydrocarbons in relation to their effects on beneficials were those of Wille, 1951; Gaines, 1954; Harris and Valcarce, 1955; Burke, 1959; Leigh et al., 1966; Laster and Brazzel, 1968; and Lingren et al., 1968.

Insecticide applications programmed according to cotton plant development rather than pest presence have been rather widely recommended since calcium arsenate came into widespread use. Isley and Baerg observed as early as 1924 that automatic arsenate applications were not effective and recommended a treat-as-needed approach. Ewing and Parencia (1949) were among those opting for the automatic scheduling. Watson and Sconyers (1965) found yield to be as great with an average of 10.5 applications per year on an as-needed basis as with 19 applications per year on a fixed schedule. Yet, according to Newsom (1970, p. 126),

> ...the majority of entomologists concerned with cotton insects and almost all industry representatives encouraged growers to adopt 'automatic' schedules of insecticide application based on the stage development of the plant with no regard for the presence of pests.

The first recognition of resistance to chlorinated hydrocarbons in the boll weevil was in Louisiana in 1955 (Roussel and Clower, 1955). Parencia and Cowen (1960) later reported increased tolerance in both the boll weevil and the cotton fleahopper to some of the chlorinated hydrocarbons. Powerful new chlorinated hydrocarbon mixtures were used where the level of resistance was not too high; in other areas, organophosphorus compounds were utilized. The devastation of beneficial populations continued with the use of this new group of insecticides (Leigh et al., 1966; Lingren and Ridgway, 1967; Ridgway et al., 1967; Lingren et al., 1968; Rechav, 1974).

The widespread reduction in predator and parasite populations contributed to chronic Heliothis spp. outbreaks in cotton over much of the Cotton Belt. During this period it was discovered that the Heliothis problem in cotton was due to two species: H. zea and H. virescens.

Folsom (1936) had recognized *H. virescens* as a cotton pest in 1934 in Louisiana, but prior to 1949 few distinctions were made between the two species in cotton and it is probable that some of the damage attributed to the bollworm was actually done by the tobacco budworm (Brazzel et al. 1953).

The difference between the two species assumed great importance when it was discovered that they differed in natural susceptibility to insecticides. Gast et al. (1956) tested the toxicity of several insecticides to *H. zea* and *H. virescens* and reported that most materials were more toxic to *H. zea* than to *H. virescens*, but that the organophosphorus compounds showed less differential than did the chlorinated hydrocarbons. The development of a low level of DDT resistance in the bollworm was documented in a 1959-61 study in Louisiana (Graves et al., 1963). Ten-fold to 40-fold increases in DDT resistance were soon reported in that state (Graves et al., 1964). Brazzel (1963) reported the first instance of the tobacco budworm as a serious cotton pest in Texas and indicated the Texas strain was highly resistant to DDT. The next year Brazzel (1964) reported DDT resistance in the bollworm in Texas. In addition, Heliothis resistance to DDT was reported in Arkansas (Lincoln et al., 1967), Mississippi (Pate and Brazzel, 1964), and Oklahoma (Lingren and Bryan, 1965). *Heliothis* resistance to carbaryl, a carbamate, also developed, along with resistance to chlorinated hydrocarbons other than DDT, such as strobane, toxaphene and endrin (Adkisson and Nemec, 1965; Brazzel, 1965; Lowry et al., 1965; Adkisson, 1968).

Lowry (1966), reporting on *Heliothis* resistance in the lower Rio Grande Valley of Texas in 1964, observed little if any resistance to methyl parathion. Studies as late as 1966 on tobacco budworms collected at College Station, Texas, revealed no resistance to organophosphorus insecticides (Adkisson and Nemec, 1967). In 1968, Carter and Phillips reported the appearance of methyl parathion resistance in a laboratory culture of *H. virescens*. This was followed shortly by observations of resistance in the field. Wolfenbarger and McGarr (1970) reported a 20-fold increase in tobacco budworm resistance to methyl parathion in the Rio Grande Valley from 1966 to 1968, with a 4-fold increase in resistance to monocrotophos. In 1970, Harris reported a 3- to 10-fold increase in methyl parathion resistance in the tobacco budworm, with no increase in the bollworm or in the boll weevil, in Mississippi. Graves et al. (1973) told of similar resistance in Louisiana. The 29th Annual Conference Report on Cotton Insect Research and Control (1976) lists the tobacco budworm as presently resistant to organophosphorus compounds in Arkansas, Louisiana, Mississippi and Texas, and the bollworm resistant to methyl parathion in Arkansas, Mississippi and Oklahoma. The bollworm is from 2 to 1000 times as susceptible to insecticides as is the tobacco budworm, depending upon the insecticide in question (Graves and Clower, 1975).

The tobacco budworm has characteristically been more abundant early in the season in Louisiana, Georgia, Arkansas and certain other areas (Brazzel et al., 1953; Graves et al., 1965; Hodges et al., 1966), with the situation somewhat reversed in Oklahoma (Bryan, 1961). However, a change in the seasonal abundance of *Heliothis* has taken place in the last few years. Tobacco budworms are now occurring with greater frequency in August and September in nearly all cotton producing states. It is also comprising a greater proportion of the *Heliothis* complex (Graves and Clower, 1975; Roussel, 1976). For example, Coppock stated in 1971 that the tobacco budworm usually made up less than 10% of the total bollworm population in Oklahoma. However, a sample of larvae collected at Chickasha, Oklahoma, on August 13, 1974, was composed of 50% H. zea and 50% H. virescens (Price et al., 1975); samples taken at that location on August 22 and September 2, 1975, were 62% H. zea:38% virescens, and 57% H. zea:43% H. virescens, respectively (Young et al., 1976).

Tobacco budworms highly resistant to both the chlorinated hydrocarbons and organophosphorus insecticides now threaten to destroy the cotton industry in southern Texas as they have essentially done in northeastern Mexico. The cotton industry in the Canete Valley of Peru was gravely threatened by the tobacco budworm until control measures not totally dependent on insecticides were instituted (Wille, 1951; Hambleton, 1944; Simon, 1954; van den Bosch, 1971). In 1974 and 1975 many of the most productive cotton farms in the Red River Valley of Louisiana suffered extreme damage by the tobacco budworm. Pesticides registered for use on cotton were unable to adequately control the devastating populations of Heliothis (Roussel, 1976). The cotton industry is presently facing one of its most formidable adversaries ever: a tobacco budworm virtually immune to available insecticides.

An Alternative Approach to the Problem

Those concerned with cotton production have been forced to look for some means other than total reliance on chemicals to control their arthropod pests. Problems of increased resistance to insecticides, not only in the Heliothis complex and the boll weevil, but in the cotton fleahopper, Lygus spp., spider mites and several other pests (29th

Annual Conference Report on Cotton Insect Research and Control, 1976), along with problems of pest resurgences and secondary pest outbreaks, have necessitated the development of alternative control procedures.

One of the alternatives being given consideration at this time is greater utilization of biological control agents in the regulation of cotton pest populations. A major obstacle to the use of this approach is the fact that the boll weevil is not especially susceptible to regulation by parasites and predators. L.O. Howard, back in 1897 (p. 5), came to the conclusion that "It is safe to say that little assistance will be derived from the work of natural enemies and parasites upon this insect." Although Howard conceded that biological control against the boll weevil would not likely be effective, there were a number of early studies on predators and parasites of the weevil, including Pierce (1908), Newell and Treherne (1908), and Hunter and Pierce (1912). Hunter and Pierce, in fact, listed 29 parasites and 28 predators of the boll weevil, but none were sufficiently efficient to adequately control the pest.

Fortunately, however, the Heliothis complex is relatively vulnerable to attacks by parasites and predators. According to Ridgway and Lingren (1972), levels of natural control of Heliothis ranging from 50% to 90% or more may be expected from predation and parasitism of eggs and larvae. Brazzel (1965) reported that parasites and predators did an excellent job of controlling spider mites and bollworms in Mississippi until early August, when insecticide applications were necessary for boll weevil control. Van den Bosch et al. (1969) reported field cage studies in which naturally occurring predators destroyed two-thirds to nine-tenths of the bollworms. Fletcher and Thomas (1943) observed

15-33% egg predation and 13-60% larval predation of *Heliothis* in cotton. Bell and Whitcomb (1962) reported similar predation levels. Reported egg parasitism rates range from 5-98% (Graham, 1970; Ridgway and Lingren, 1972), whereas larval parasitism has been reported from 0-51% (Quaintance and Brues, 1905; Bottrell et al., 1968; Lewis and Brazzel, 1968; Young and Price, 1975).

Many species of predators and parasites are known to attack *Heliothis* spp. About 600 beneficial species were recorded in Arkansas cotton from 45 families of insects, 19 of spiders and four of mites (Whitcomb and Bell, 1964). Over 350 species of parasites and predators were found in California cotton (van den Bosch and Hagen, 1966). Bottrell et al. (1968) reported 15 species of parasites of *Heliothis* in Oklahoma. The complex of predators and parasites exerting control on *Heliothis* varies with the crop, time of year, locality, etc. The most important of the predators are in 10-15 families, including perhaps most notably the Lygaeidae, Nabidae, Anthocoridae, Chrysopidae and Coccinellidae among insects and Argiopidae, Oxyopidae, Salticidae and Thomisidae among spiders. Parasites are predominantly from four families: Braconidae, Ichneumonidae, Trichogrammatidae and Tachinidae (Ridgway and Lingren, 1972).

One problem encountered in the utilization of biological control agents for effective cotton pest regulation is that an adequate build-up of beneficial populations often does not occur early enough in the season to prevent substantial damage. One method of overcoming this problem may be the augmentation of naturally occurring predator and parasite populations by field release of laboratory raised organisms, as has been done with *Chrysopa carnea* Stephens (Ridgway and Jones, 1968a) and Trichogramma minutum Riley (Fye and Larsen, 1969) for Heliothis control. Removing the lag between the build-up of Heliothis and that of its natural control agents has also been attempted by providing greater sources of food and hosts for the predators and parasites of the pest (Pickle, 1973).

Diversifying cropping systems to promote beneficial populations is another way of enhancing natural control. A number of studies have involved creating a more diversified habitat by interplanting cotton with an alternate crop which serves as an insectary for natural enemies of cotton pests; in some instances, the alternate crop may also serve as a trap crop to attract pests away from cotton. In California, interplanting cotton with alfalfa is being studied for Lygus bug control in the cotton. The Lygus bug has a distinct preference for alfalfa over cotton; also, populations of natural enemies develop in the alfalfa and then attack lepidopterous pests in the adjacent cotton (Stern et al., 1969; Sevacherian and Stern, 1974).

The idea of interplanting to promote beneficial populations is not new. It was recommended for plant lice control in 1935 by Marcovitch, who remarked that

> The problem, therefore, is that of devising agricultural practices that will increase the effectiveness of the natural enemies already present; and of maintaining a relatively high level of parasites and predators through the judicial management of environmental factors (p. 62).

Simon (1954) reported on interplanting cotton with maize in Peru for H. virescens control, pointing out that the maize encourages breeding of natural enemies of the pest.

In southeastern Missouri, DeLoach and Peters (1972) compared beneficial populations in solid-planted cotton with those in cotton strip-planted with such crops as alfalfa, corn, oats and soybeans. Although there were no statistically significant differences in populations of predators between the solid- and strip-planted areas, they indicated there were 'trends toward greater control' in the more diversified habitat.

Studies were conducted in southwestern Oklahoma in 1969 and 1970 in an attempt to determine which crop would be of most value in an interplanting scheme with cotton in that area. Five crops (corn, alfalfa, grain sorghum, soybeans, and peanuts) were used. Based upon the numbers of predators present and the yield obtained, Robinson et al. (1972a, b) recommended grain sorghum as having the greatest potential for use in such a scheme. Fye and Carranza (1972) discussed grain sorghum-cotton interplanting as a means of enriching predator populations in Arizona cotton. The importance of proper coordination of sorghum maturity with cotton squaring was emphasized. Massey (1973) determined that a 12:4 array of cotton:grain sorghum was the optimum ratio of cotton to sorghum in Oklahoma, with a 24:4 array second best. He stressed that populations of aphids and fall armyworms, Spodoptera frugiperda (J.E. Smith), should begin to decline in the sorghum as squaring of the cotton occurs. In 1976, Lopez and Teetes reported on the relation of aphid predators in grain sorghum to cotton in Texas. They noted that as the aphid populations decreased in the sorghum, the predator density also decreased in that crop, while at the same approximate time predator populations began to increase in adjacent cotton.

It appears, then, that interplanting cotton with grain sorghum is a feasible means of increasing populations of beneficials in cotton in certain areas and may, therefore, provide an an alternative to the use of chemicals for some part of the insect pest control necessary in cotton production.

CHAPTER III

MATERIALS AND METHODS, 1973

Studies were conducted at the Oklahoma State University Irrigation Research Station located in Jackson County near Altus, Oklahoma, during the growing season of 1973. Six plots were used, each 116 rows wide and 425 feet long. A 15-row buffer zone extended along both sides of each plot. Rows were planted with 40-inch spacing. Three insect control schemes were assigned to plots according to a randomized block design, with each scheme occurring once in each of the two blocks. The three schemes were as follows:

1. Insecticide: solid-planted cotton with insecticide applications according to recommendations of the Oklahoma State University Agriculture Extension Service (Young et al., 1973),
2. Strip-planting: cotton interplanted with grain sorghum; no insecticide applications, and
3. Control: solid-planted cotton; no insect control measures applied.

The cotton variety Westburn 70 was planted May 28, 1973, at a rate of 20 pounds per acre. In the interplanted plots a 24:4 array of cotton: sorghum was used. The sorghum variety Acco R1090, a medium maturing variety, was planted at a rate of eight pounds per acre on May 28.

Plots were irrigated three times during the growing season, on July 25, August 9 and August, with approximately three inches of water per irrigation. Station records showed a total of 8.03 inches of rainfall received during the months of May through August, distributed as follows: May--2.18; June--3.08; July--2.69; August--0.08.

Plant densities were estimated for each scheme by counting the plants in 40 random samples per plot. Each sample consisted of a 10-foot linear section of row. Counts were then extrapolated to a 'per acre' basis, resulting in estimated stands as follows:

Insecticide scheme	30,378 plants per acre
Strip-planted scheme	37,899 plants per acre
Control scheme	36, 132 plants per acre

Those plots designated to receive chemical insect control measures received two applications of insecticides: 1) dimethoate at 0.22 pound AI per acre on July 10 for cotton fleahopper control, and 2) toxaphene: methyl parathion 4:4 at one pound of each per acre on August 3 for control of Heliothis spp.

Data were collected weekly by whole-plant examinations, starting June 26 and continuing through August 31. One plant was inspected from each cotton row each week, for a total of 656 plants per week. The location of each plant to be inspected was determined by use of a computer-generated listing of random numbers designating distances along each row. Different locations were used each week. Predator data were collected on lady beetles (primarily Hippodamia spp.), green lacewing eggs, larvae and adults (Chrysopa spp.), Collops (Collops spp.), big-eyed bugs (Geocoris spp.), nabids (Nabis spp.), hooded flower beetles (Notoxus monodon F.), and spiders. Numbers of cotton fleahoppers were recorded but not numbers of fleahopper-damaged fruits. Records of fruit damage by the Heliothis complex and by the boll weevil were kept.

Plant fruiting characteristics recorded were numbers of squares, blooms and bolls.

Cotton yields were obtained by harvesting the entire plots with a mechanical stripper on January 2, 1974.

Analyses of variance of insect and spider data, fruiting characteristics and fruit damage were made in the Oklahoma State University Computer Center utilizing the Statistical Analysis System Program.[1] Data were converted to a per acre basis prior to analysis. Differences were declared significant at the 0.10 level of probability.

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[1]The system was designed and implemented by Anthony J. Barr and James H. Goodnight, Department of Statistics, North Carolina State University, Raleigh, North Carolina.

CHAPTER IV

RESULTS AND DISCUSSION, 1973

Predatory Arthropods

Table I, p. 67, lists the weekly average numbers per acre of predatory arthropods for each scheme. Included in these totals are numbers of spiders, lady beetles, green lacewing larvae and adults, nabids, big-eyed bugs, Collops and hooded flower beetles. The weekly estimates ranged from a low of 655 predators per acre in the insecticide scheme on June 26 to a high of 33,952 in the strip-planted areas on July 25.

The strip-planted scheme had the highest weekly average predator totals on nine of the ten sampling dates; however, differences among schemes were significant only on July 10 and 25 and August 7. On July 10, the insecticide and control totals were not different from each other, and the strip-planted total was higher than either; on July 25, all schemes were significantly different from each other, with the insecticide total lowest and the strip-planted highest; on August 7, the insecticide total was lowest and the control and strip-planted totals were higher and not different from each other. Overall totals for the 10-week observation period showed all schemes to be significantly different, with the insecticide scheme lowest and the strip-planted scheme highest. The insecticide scheme had 49% as many predators overall as did the strip-planted scheme; the control scheme had 79% as many as the strip-planted scheme.

Although the numbers of total predators were considerably larger in the strip-planted and control areas than in the insecticide scheme, the various predator groups accounted for similar percentages in all three schemes. In other words, it was primarily the abundance of predators that varied, rather than the relative composition of the predator complex in the different schemes. This was especially true of the two most abundant groups, spiders and lady beetles, as shown in Fig. 1, p. 99. Spiders were the most abundant predators, accounting for 64.8% of the total predators in the insecticide and strip areas and 68.1% in the control plots. Lady beetles, the second most abundant predators, made up 12.7%, 13.0% and 13.9% of the total predators in the strip-planted, insecticide and control schemes, respectively.

The percentages of the less frequently encountered groups in each scheme are shown in Fig. 2, p. 100. The green lacewings constituted a greater overall percentage in the insecticide scheme, making up 11.2% of the predators in that scheme, compared to 8.3% and 7.6% in the strip-planted and control schemes, respectively. The insecticide plots had more lacewings relative to the strip-planted plots (67%) than any other predator group; this may have been coincidental or it may have been a reflection of the lower susceptibility of the genus *Chrysopa* to many insecticides, relative to other predaceous arthropods (Eveleens et al., 1973; Burke and Martin, 1956; van den Bosch et al., 1956).

The strip-planted plots had a somewhat greater percentage of their total predator complex supplied by the relatively scarce big-eyed bugs, hooded flower beetles, *Collops* and nabids than did the other areas. This could perhaps be attributed to the fact that the interplanted areas provided a more diverse habitat which encouraged a greater variety of populations to develop.

The seasonal trends of the relative contributions of the three most abundant predator groups to the total predator complex in the different schemes are shown in Fig. 3, 4 and 5, on p. 101, 102 and 103, respectively. A comparison of the three figures shows the relatively greater role played by lady beetles in the strip-planted plots during the first three observation periods as compared to their roles in the other areas where spiders were more important. Lacewings assumed somewhat greater importance in the insecticide areas earlier than in the other schemes. In all three schemes, lacewings were late-season predators. Spiders were more constant in their percentage contribution to the total predator complex than were either lady beetles or lacewings.

Table II, p. 68, lists weekly average numbers of spiders per acre for each scheme. The lowest number of spiders recorded was 197 per acre on the first sampling date, June 26, in the strip-planted areas; the highest was 23,687 per acre on July 25, also in the strip-planted areas. Only on July 25 were differences among schemes significant, with the strip-planted having the greatest numbers of spiders and control and insecticide having fewer and not being different from each other. On an overall basis, there was no significant difference between numbers of spiders in the control and strip-planted areas, both of which had more than the insecticide areas. The insecticide and control schemes had 49% and 83%, respectively, as many spiders as did the strip-planted scheme. Because spiders are rather indiscriminate predators, consuming both beneficials and pests, their actual contribution to pest control might not correspond to their numerical predominance.

Table III, p. 69, lists average weekly lady beetle totals per acre for each scheme. Lady beetle populations ranged from none being detected in six instances to a high of 7303 per acre on July 10 in the strip-planted areas. On six of the ten sampling dates, the control scheme had the most lady beetles; however, during the only two periods when differences among schemes were significant, the strip-planted plots had the greatest numbers, with the insecticide and control averages lower and not different from each other. The overall total of lady beetles was significantly lowest in the insecticide scheme, with the numbers in the control and strip-planted schemes not different from each other. The insecticide and control areas had 50% and 87%, respectively, as many lady beetles as were found in the strip-planted areas. The abundance of lady beetles in the strip-planted plots in July was likely correlated with the proximity of the sorghum interplanted with the cotton. Movement of lady beetles and other predators from sorghum to adjacent cotton as populations of aphids and other prey organisms decline in the sorghum has been reported in Arizona (Fye and Carranza, 1972), Oklahoma (Massey, 1973) and Texas (Lopez and Teetes, 1976).

Table IV, p. 70, gives weekly averages of green lacewing larvae and adults in each scheme. Both larvae and adults were first encountered on July 17, during the fourth sampling. No significant differences occurred among weekly scheme averages; on an overall basis, the number of adults was significantly highest in the strip-planted scheme and lowest in the insecticide scheme, with the control total not different from either of the other treatment totals. There were no differences in overall larvae numbers.

Numbers of green lacewings, especially the adults, were very low throughout the period of observation, with a high of 3356 larvae per acre on August 31 in the strip-planted areas and 1184 adults on July 31, also in those areas. Campbell and Hutchins (1952) suggested that field counts of lacewing adults are probably lower than the true value because the slightest disturbance causes them to fly. Lincoln and Leigh (1957) suggested that the low numbers of these insects recorded in field studies might be due to adults being more active at night than during the day.

Numbers of lacewing eggs were recorded each week after their first appearance during the second sampling on July 3; average weekly numbers of eggs are given in Table V, p. 71. No larvae or adults were seen until two weeks after the first eggs were noticed; obviously there had been some adults in the fields at least two weeks before any were recorded. The sampling procedure was perhaps inadequate for accurately defining the populations of these organisms. From July 17 through the final sampling on August 31, large numbers of lacewing eggs were found, with an estimated 72,982 on August 14 in the strip-planted areas as the highest weekly average. Differences among schemes were significant on July 17 and 25, with control highest, insecticide lowest, and strip-planted not different from either on the first date, and all three different on the second date, with strip highest and insecticide lowest. No differences occurred in overall totals. Based on the totals for all schemes combined, an eggs:larvae ratio of 26.3:1 was obtained. Lincoln and Leigh (1957) observed that green lacewing eggs are frequently abundant in cotton when both larvae and adults are scarce. They suggested this might indicate excessive mortality of active forms, or, as mentioned earlier, that adults are more active at night and so escape notice.

Table VI, p. 72, gives weekly average numbers of the hemipteran predators included in this study: big-eyed bugs and nabids. There were no significant overall differences among schemes; however, highest numbers of both occurred in the strip-planted areas. These predators tended to be more common during the first half of the observation period. Laster and Brazzel (1968) mentioned these two groups as being early season predators whose populations decline in late season. Big-eyed bugs accounted for an average of 3.2% 1.8% and 4.1% of the total predators in the insecticide, control and strip-planted schemes, respectively. Nabids made up 5.0%, 5.7% and 5.6% of the predators in insecticide, control and strip-planted schemes, respectively.

Table VII, p. 73, lists average weekly numbers of Collops and hooded flower beetles. Even lower numbers of these were encountered than of big-eyed bugs and nabids. Collops accounted for 2.1%, 2.3% and 3.3% of overall predators in insecticide, control and strip-planted areas, respectively. Hooded flower beetles accounted for only 0.6%, 0.5% and 1.3% in insecticide, control and strip-planted areas, respectively.

It is likely that populations of the relatively scarce predators were not accurately estimated. As Allen et al. (1972) pointed out, increasingly large numbers of samples are required for estimating lower level populations. As Hansen et al. (1953) observed, when one is studying more than one variable, the usual practice is to take a sample which is adequate for the most important variables and accept whatever precision is attained for the less important ones.

Figure 6, p. 104, illustrates the seasonal trends of the estimated weekly averages of total predators in each scheme. As was evident in Table I, p. 67, the largest number of predators occurred in the strip-planted areas on every sampling date except August 7. The seasonal trends were, in general, quite similar in all three schemes. Differences among treatments were largely of magnitude, not of the developmental pattern of the predator complex.

The decline in total predators on July 17 in the insecticide plots was most probably a result of the dimethoate application on July 10 for cotton fleahopper control, especially since there were no concommitant declines in the other areas. A number of studies have shown systemics to be harmful to beneficials (Bariola et al., 1971; Rummel and Reeves, 1971; Walker and Niles, 1971; Timmons et al., 1973). Eveleens et al. (1973) specifically discussed the destructive action of dimethoate, which acts both as a contact and a systemic insecticide, on predator populations.

An examination of Fig. 7, p. 105, which shows patterns of lady beetle populations, and Fig. 8, p. 105, showing spider population trends, indicates that the lady beetles were more affected than the spiders by the initial chemical treatment and suggests that the decline on July 17 in total predators in the target plots was mainly due to a decline in lady beetles. Ridgway et al. (1967) reported that spiders are less affected by systemics than are many other predators.

A major decline in predators occurred in all three schemes between the sampling on July 31 and that on August 7 (Fig. 6, p. 104). A spray application of toxaphene:methyl parathion was made August 3 to the insecticide plots for <u>Heliothis</u> control. This application would have conveniently explained the decline in the treated plots had not similar declines occurred in both the control and strip-planted areas as well.

The lady beetle populations began to decline in all schemes during the week prior to the spray application for Heliothis control. This could have been caused by migration of the beetles from the experimental plots; they had previously moved from the strip-planted areas of their earliest abundance into the solid-planted cotton (Fig. 7, p. 105). Environmental factors may have played a major role in causing the lady beetle decline. Between July 25 and July 31, the experimental plots were irrigated with approximately three inches of water; additionally, 2.2 inches of rain fell on the plots that week, with 1.55 inches of that being received the day before the July 31 data were collected. The excess water may have affected the beetle populations.

The decline of both lady beetles and spiders during the period from July 31 to August 7 may have been in part a reaction to the combination of rain and irrigation, or may have been a manifestation of normal population cycling. Another possible explanation is that drift of the insecticide applied on August 3 may have occurred from the target plots to the control and strip-planted areas. There appears to have been little indication of drift from the first insecticide application of dimethoate on July 10, but that does not rule out the possibility of drift being important from the toxaphene:methyl parathion application on August 3. Losses of 83%, 91% and 100% in lady beetle populations were sustained from July 31 to August 7 in the control, insecticide and strip areas, respectively. A comparison of Fig. 7, p. 105, and Fig. 8, p. 105, with Fig. 6, p. 104, indicates that the difference between the total predators in the insecticide areas and the totals in the other areas on August 7 was largely due to differences in the spider component of the predator complex, rather than in the lady beetle component. While the control and strip-planted areas had decreases in spider numbers from July 31 to August 7 of 59% and 57%, respecitvely, the loss in the insecticide-treated areas was 94%. The differential loss may have been due to the greater effect of the insecticide on the spiders in the target plots; the rather substantial losses in the other areas may have been caused by environmental conditions, insecticide drift or normal population cycling, as mentioned previously. Although Glick and Lattimore (1954) reported spiders not much affected by a toxaphene:DDT mixture, Laster and Brazzel (1968) and Lingren et al. (1968) reported that toxaphene is especially destructive to spiders.

A smaller part of the predator loss can be accounted for by considering the less abundant predators, especially the green lacewings and the hemipterans. Although green lacewings are reported to be relatively low in susceptibility to insecticides (Burke and Martin, 1956; van den Bosch et al., 1956; Eveleens et al., 1973), both larvae and adults were absent from the insecticide plots following the toxaphene: methyl parathion application on August 3, as reflected in the August 7 count. The hemipteran predators have often been cited as being especially sensitive to insecticides (Campbell and Hutchins, 1952; Ridgway et al., 1967; Laster and Brazzel, 1968; Lingren and Ridgway, 1967; Eveleens et al., 1973). Ridgway et al. (1967) reported specifically that hemipteran predators in the genera Geocoris and Nabis are extremely sensitive to systemics. Predaceous species of these genera are also reportedly plant feeders (Stoner, 1970, 1972; Ridgway and Jones, 1968b) and would be more likely to come into contact with a systemic poison than would a purely entomophagous predator. Populations of these genera (big-eyed bugs and nabids) were reduced to zero in the insecticide-treated plots on August 7 following the toxaphene:methyl parathion application. Decreases also occurred in the other areas.

As van den Bosch et al. (1956) pointed out, small plots give rise to a number of problems in relation to testing the toxicity of insecticides to beneficials. Specifically mentioned were problems of migration of beneficial species between treatments and of insecticidal contamination from plot to plot during application. However, Harding et al. (1975) evaluated plot sizes for the study of cotton arthropods in Texas. Using untreated controls and two different chemical regimes on various plot sizes, they reported no significant differences in arthropod numbers between plot sizes ranging from 0.05 acre to 8.2 acres. They did show significant differences between insecticide treated plots and untreated checks in the various sizes of plots. Their 'conservative' conclusion was that plots of about two acres can be used to adequately measure insecticide effects on beneficial arthropods. By this estimation, the study plots used in the 1973 studies at Altus should have been adequately large to allow a correct assessment of the insecticide treatments on predator populations. Because the insect fauna varies from place to place, having fields widely enough separated to insure absolutely no chemical drift would also mean risking increased variation between plots because of differences in soil, fertility, watering, plant development, etc.

There seems to have been a correlation between the declines in predator populations and the two insecticide applications (July 10 and August 3). However, not all of the differences among schemes in predator populations were due to detrimental effects of insecticides on beneficials. The more diverse habitat in the interplanted areas apparently encouraged greater development of predator populations and thereby contributed to the differences observed among schemes.

Cotton Fleahoppers

Average weekly numbers of cotton fleahoppers per acre in each scheme are listed in Table VIII, p. 74. The lowest population estimate was zero in the insecticide scheme on August 14; the highest estimate was 12,308 on July 10, also in the insecticide scheme. On those dates when differences among schemes were significant (July 17, August 7 and 14), lowest numbers were in the chemically treated plots, except on August 7 when there was no difference between the chemically treated and the interplanted areas. The estimate of over 12,000 per acre in the insecticide scheme on July 10 was sufficiently high to warrant the use of chemical control measures. Dimethoate was applied at a rate of 0.1 pound AI per acre in those plots. On an overall basis, numbers of cotton fleahoppers were significantly lowest in the insecticide treated plots and highest in the control, with the strip-planted total not different from that of either other scheme.

The cotton fleahopper was once considered a major menace to cotton production. According to Reinhard (1926, p.1),

> In localities where the cotton fleahopper has demonstrated its ability to produce injury to the cotton crop, the unanimous opinion of growers has been that this insect is more destructive than the boll weevil.

However, as early as 1941, Hamner pointed out that the cotton plant has the inherent capacity to overcome loss caused by the cotton fleahopper. Brett et al. (1946) reported that cotton fleahoppers seldom reduce cotton yields in Oklahoma and that control efforts were generally not necessary. Walker et al. (1970) observed that insecticides applied at rates sufficient for fleahopper control reduce beneficial populations. Young and Price (1970) recommended against spraying for cotton fleahopper and thrips control in Oklahoma unless very large numbers are present.

Reinhard (1926) indicated that cotton fleahoppers were generally not held in check by natural control agents. Young (1969), however, listed a number of fleahopper predators, including nabids, hooded flower beetles and big-eyed bugs. It appears that there may have been some measure of control exerted by biological agents in the present study in view of the fact that the strip plots, which had the largest predator populations, were intermediate in cotton fleahopper populations, having more than the insecticide areas but fewer than the control areas.

Figure 9, p. 106, depicts the somewhat similar trends in cotton fleahopper populations in all schemes. The considerably lower number of fleahoppers in the strip scheme than in the other schemes on July 10 could be a reflection of the fact that the predator complex in the strip-planted areas significantly exceeded that in the other areas on that date. Population peaks occurred in all schemes on July 10 and 25. The decline from July 10 to July 17 probably resulted in part from the dimethoate application since it was much more pronounced in the chemically treated plots. Declines of a lesser degree in the strip-planted and control areas may reflect insecticide drift and/or normal population cycling. The second fleahopper population peak on July 25 may have represented a new generation of fleahoppers. Few nymphs from eggs laid by the large populations on July 10 would have been obvious at the time of the sampling on July 17, but by the 25th of July, the young fleahoppers would have been rather abundant. (According to Young, 1969, cotton fleahopper eggs typically require seven to eight days for hatching, then the nymphs remain around the plant for about 11 days before beginning to fly from place to place as adults).

No attempt was made to determine the numbers of squares damaged by the cotton fleahopper. As mentioned by Barnes et al. (1973), fruit loss caused by the cotton fleahopper is difficult to distinguish from loss caused by excessive moisture, cloudy weather, boron deficiency, excess nitrogen and a number of other factors.

Damage Caused by the *Heliothis* Complex

According to Brazzel et al. (1953), damage to cotton fruits resulting from the action of the cotton bollworm is not distinguishable from that caused by the tobacco budworm. In this study, therefore, damage by both the bollworm and the tobacco budworm was recorded together as '*Heliothis*-damaged fruits.'

Table IX, p. 75, lists the average numbers per acre of *Heliothis*-damaged fruits (bolls and squares) and also the per cent of total fruits damaged by *Heliothis* spp. in each scheme each week. No *Heliothis* damage was detected until July 17, when only 156 fruits per acre were damaged in the control scheme. The greatest number of damaged fruits (40,860) occurred on August 14 in the strip-planted areas; this amounted to 4.32% of the fruit present in those areas on that date. The greatest per cent damage occurred on July 31 when 6.4% of the fruits in the insecticide scheme were damaged. Only on July 31 was there a significant difference among schemes in the amount of *Heliothis* damage sustained;

on that date, damage was greater in the insecticide treated plots than in plots of either other scheme. On an overall basis, there were no significant differences among schemes in the numbers of Heliothis-damaged fruits. Figure 10, p. 107, and Fig. 11, also on p. 107, show graphically the numbers of damaged fruits and the per cent of total fruits damaged. A comparison with Fig. 6, p. 104, showing trends in total predators, shows that the marked decline in beneficials in the chemically treated plots on July 17 preceded by two weeks the extensive Heliothis damage sustained in those plots as compared to that in the the other areas which had not undergone a corresponding decline in predators. This provides a strong indication of a definite correlation between predator population decrease and Heliothis increase. Such correlations have been reported by a number of workers, including Ridgway et al., 1967; Bariola et al., 1971; and Timmons et al., 1973. The early outbreak of Heliothis in the chemically treated plots emphasizes the desirability of withholding insecticide treatments for early season pests such as cotton fleahoppers unless absolutely necessary.

The Heliothis damage in the insecticide scheme on July 31 was considered sufficient to warrant the use of chemical control measures. Toxaphene:methyl parathion 4:4 was applied at a rate of one pound of each per acre on August 3. Damage declined immediately after the insecticide application in the treated plots, but by the third week following the application, the treated areas were sustaining greater damage than either the control or strip-planted areas. Although all three schemes registered declines in the numbers of Heliothis-damaged fruits from August 21 to August 31, the per cent of total fruits damaged actually increased during that period in all but the strip planted areas. At no time during the observation period did the per cent damage in the strip-planted areas rise above the treatment threshold recommended by the Oklahoma State University Agriculture Extension Service (Young et al., 1973) of 10% damage in July and 5% damage in August. (Because the 6.43% damage in the insecticide scheme was recorded on July 31, it was deemed advisable to abide by recommendations for August). The threshold of 5% damage in August was exceeded once in the control scheme, two weeks later than treatment had been necessary in the insecticide plots. As previously mentioned, the destruction of predators by the first insecticide application on July 10 more than likely accounted for the early rise to prominence of *Heliothis* in the treated plots.

Damage Caused by the Boll Weevil

Damage resulting from feeding and ovipositing of boll weevils was practically nonexistent in the experimental plots. Only four instances of boll weevil damage were recorded; the greatest of those was an estimated 525 damaged fruits per acre in the insecticide treated plots on August 31.

Fruiting Characteristics

Table X, p. 76, gives average weekly numbers per acre of squares in each scheme. On July 10, 17 and 25, the number of squares in the strip plots was significantly higher than in the insecticide plots, and significantly higher than in the control plots also on the 17th and 25th. However, on July 31 the strip plots had significantly fewer squares than either other scheme. Overall totals showed somewhat more squares in the strip-planted areas than in the other areas, but not significantly more.

Average numbers of blooms per acre are recorded in Table XI, p. 77. Numbers of blooms were significantly different only on August 8, when the insecticide treated plots had fewer than plots of either other scheme. The chemically treated plots tended to lag consistently behind the strip-planted plots in number of blooms, but no significant overall differences among schemes were detected.

Table XII, p. 78, lists average weekly numbers of bolls per scheme. Only one weekly difference was significant (August 21), with strip-planted areas having the most bolls and insecticide and control areas lower and not different from each other. No differences among the overall scheme totals were significant.

As illustrated in Fig. 12, p. 108, and Fig. 13, p. 109, production of squares and bolls followed very similar patterns in all schemes. More variation occurred in square production, where no one scheme led consistently, than in boll production, where the strip-planted scheme consistently led. The insecticide scheme generally was lowest in boll production; it surpassed the control scheme boll production only on the August 14 sampling date. There is evidence that methyl parathion can slow cotton maturity by five to ten days (Mistric et al., 1970). In this study, however, the insecticide scheme boll production was lower than that in the other schemes even prior to the application containing methyl parathion; in fact, it was after that application that the insecticide total exceeded the control total for one week. It is doubtful, then, that the differences in boll production can correctly be attributed to the effect of methyl parathion. No account of the effect of dimethoate on cotton maturity was found in the literature so its role cannot be accurately assessed at this time. The differences in boll production which were exhibited among the three schemes could be merely coincidental, but the development of such a consistent pattern seems to indicate the operation of some factor other than chance. It may be that some unexplained factor was operating to increase production in the strip-planted areas or that the greater predator populations in the strip-planted areas minimized square loss to pests and thus promoted the formation of more bolls.

Yield

Table XIII, p. 79, lists stripper-harvested cotton yields per plot and per acre for each scheme. The strip-planted scheme, with 96 rows (3.12 acres) of cotton in each plot, produced more cotton per plot than either of the other schemes, both of which had 116 rows (3.77 acres) of cotton per plot. In addition to the greater per plot cotton yield, the strip plots produced 3550 pounds and 3350 pounds of grain sorghum in blocks #1 and #2, respectively, for an average sorghum yield of 1408 pounds per acre in a 24:4 cotton:sorghum array, or 5308 pounds per acre of sorghum. The average yield per acre of cotton in the strip-planted scheme was 1173 pounds more than that in the control scheme and 1299 pounds more than that in the insecticide scheme.

Analysis according to a randomized block design indicated no significant differences in cotton yield on either a per plot or per acre basis. However, block effects were negligible (F for blocks on per plot basis = 0.1812, on a per acre basis = 0.1070, compared with F = 8.53 required for significance at the 0.10 level of probability).

Therefore, analysis on a completely randomized design was justified (Table XIV, p. 80). On that basis, the strip-planted scheme per acre cotton yield was greater at P = 0.10 than the yield of either of the other schemes. Yields in the control and insecticide schemes were not significantly different from each other.

CHAPTER V

MATERIALS AND METHODS, 1974

Studies were conducted during the 1974 growing season at the Oklahoma State University Southwest Agronomy Research Station, near Tipton, Oklahoma, in Tillman county. The three insect control schemes utilized were the same as were used in 1973 at Altus, Oklahoma, namely:

1. Insecticide: solid-planted cotton with insecticide applications according to recommendations of the Oklahoma State University Agriculture Extension Service (Young et al., 1974),
2. Strip-planting: cotton interplanted with grain sorghum; no insecticide applications, and
3. Control: solid-planted cotton; no insect control measures applied.

Twelve plots were used. Each plot was 20 rows wide and 230 feet long, with 40-inch row spacing. A randomized block design was used, with each of the three schemes occurring once in each of four blocks.

The cotton variety Thorpe was planted on May 9, 1974, at a rate of 20 pounds per acre. In the interplanted plots, the four outer rows on each side were planted with Acco R1090 grain sorghum, a medium maturing variety, at a rate of 12 pounds per acre. The 12 center rows of the interplanted plots were planted with cotton, making a 4:12:4 array.

Plots were irrigated twice, on July 10 and August 1, with approximately three inches of water per irrigation. A total of 10.02 inches of rain fell at the station during the months of May through August, distributed as follows: May--0.35; June--3.59; July--0.37; August--5.71.

The plots designated to receive chemical insect control were given seven applications of insecticides:

1. July 15: dimethoate at 0.1 pound AI per acre for cotton flea-hopper control,
2. July 26: dimethoate at 0.1 pound AI per acre for cotton flea-hopper control,
3. August 14: azinphosmethyl at 0.25 pound AI per acre for boll weevil control,
4. August 19: azinphosmethyl at 0.25 pound AI per acre for boll weevil control,
5. August 22: azinphosmethyl at 0.50 pound AI per acre for boll weevil control,
6. September 9: methyl parathion at 0.5 pound AI per acre for boll weevil control, and
7. September 12: methyl parathion at 0.5 pound AI per acre for boll weevil control.

Data were collected weekly by whole-plant examinations, starting June 10 and continuing through September 7. A 'sample' consisted of all plants in five linear feet of row. Six such samples were taken each week in each of the 12 plots. The outer four rows on each side of the solid-planted plots were not sampled. Locations of the sampling sites were determined by use of random numbers tables to designate row number and distance along row to sampling site. Different locations were used each week.

Predator data were collected on lady beetles, green lacewing eggs, larvae and adults, Collops, big-eyed bugs, nabids, hooded flower beetles and spiders. Numbers of cotton fleahoppers were recorded, as were numbers of Heliothis larvae. Fruit damage by the Heliothis complex and by the boll weevil was recorded. Plant fruiting characteristics included were numbers of squares, blooms and bolls.

Cotton yields were obtained by harvesting the 12 central cotton rows per plot (equivalent to 0.21 acre of cotton per plot) with a mechanical stripper on December 6, 1974.

Analyses of variance of insect and spider data, fruiting characteristics and fruit damage were made in the Oklahoma State University Computer Center using the Statistical Analysis System Program.[1] Data were converted to a per acre basis prior to analysis by multiplying the original counts by 2613.6. (Number of row feet of 40-inch spacing per acre = 13,068; number of feet per sample = 5; 13,068/5 = 2613.6). Differences among schemes were declared significant at the 0.10 level of probability.

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[1]The system was designed and implemented by Anthony J. Barr and James H. Goodnight, Department of Statistics, North Carolina State University, Raleigh, North Carolina.

CHAPTER VI

RESULTS AND DISCUSSION, 1974

Predatory Arthropods

Table XV, p. 81, lists the weekly average numbers of predatory arthropods per acre in each scheme. The same groups are included as were discussed in Chapter IV regarding similar studies at Altus, Oklahoma, in 1973: spiders, lady beetles, green lacewing larvae and adults, nabids, big-eyed bugs, Collops and hooded flower beetles. Differences among the scheme predator averages were insignificant on only four of the 13 sampling dates. At all other times, the numbers were either significantly greater in the strip-planted scheme than in either other scheme (five times) or were greater than those in the insecticide treated plots but not different from those in the control plots (four times). On an overall basis, the strip-planted scheme had significantly more predators than either other scheme.

There was less relative difference between the insecticide scheme and the strip-planted scheme in the Tipton studies than had existed at Altus in 1973. At Tipton, the insecticide areas had 62% as many predators as the strip-planted areas, compared to 49% as many at Altus. The control areas had 75% as many predators as the strip-planted areas at Tipton, but had had 79% as many at Altus.

As shown in Fig. 14, p. 110, Collops, lady beetles and spiders all accounted for large proportions of the total predator complex in each scheme. No one group approached the relative dominance displayed by spiders at Altus during the 1973 studies. Collops, which had been scarce at Altus, made up 25% of the overall total predators in the insecticide scheme, 26% in the control and 29% in the strip-planted. Lady beetles made up 21% of the predators in the control, 23% in the insecticide and 29% in the strip-planted scheme. Spiders, the third most common group, accounted for 19%, 23% and 25% of the predators in the strip-planted, control and insecticide schemes, respectively. As indicated in Fig. 15, p. 111, hooded flower beetles also made up an important part, numerically, of the predator complex in each scheme, providing 19% of the total in the insecticide, 20% in the control and 14% in the strip-planted areas. The combined numbers of the less common predators (nabids, big-eyed bugs and green lacewings) made up less than 10% of the predator total in each scheme.

Figure 16, p. 112, Fig. 17, p. 113, and Fig. 18, p. 114, illustrate the relative abundances of the three most common predator groups in the different schemes throughout the season. Collops exhibited extremely similar trends in all three schemes, being relatively unimportant during the early part of the season, then contributing a major proportion of the total predators in mid-season and undergoing a relatively rapid decline in mid-August and remaining somewhat numerically insignificant for the remainder of the observation period. Lady beetles were relatively more important in the strip-planted scheme than in the other areas early in the season, but assumed a level of importance later in the season that was much the same in all schemes. Spiders were more important in all schemes during the latter part of the observation period than earlier in the season.

Table XVI, p. 82, lists the estimated average numbers of Collops per acre in each scheme. Collops were typically more numerous in the strip-planted areas, reaching a high of 36,264 per acre there on July 29. The strip-planted plots had significantly more Collops than the insecticide plots on four sampling dates: July 16, 19 and August 6, 20. Twice the numbers of Collops in the strip-planted plots were also greater than in the control plots; on the other dates, there was no difference between strip-planted and control averages. On an overall basis, significantly more Collops occurred in the strip-planted areas than in either the control or the insecticide treated areas. The insecticide areas had 54% as many Collops as the strip-planted areas; the control areas had 67% as many as the strip-planted. Figure 19, p. 115, and Fig. 20, p. 115, showing weekly numbers of Collops per scheme and per cent of the predator complex composed of Collops, respectively, illustrate information that has already been presented in Table XVI, p. 82, and Figs. 16, 17 and 18, on pages 112, 113 and 114, respectively. These figures are included because they provide a good example of a point made in relation to the predator situation in the 1973 studies at Altus: for the most part, it appears to be the absolute abundance of a predator group that varies from scheme to scheme, not the pattern of population development or the relative importance of that group to the predator complex in the different schemes.

Collops not only feed on Heliothis eggs and larvae, aphids and other small insects, but according to Young (1969), they also sometimes consume boll weevil larvae. The boll weevil is especially resistant to control by predators and parasites. In fact, in his discussion of insects beneficial to cotton, Young mentioned only Collops as feeding on boll weevil larvae.

Average numbers of lady beetles per acre in each scheme are listed in Table XVII, p. 83. On six of the 13 sampling dates, there were significantly more of these insects in the interplanted areas than in either the control or chemically treated areas, which were not different from each other. The strip-planted scheme also had significantly more lady beetles on an overall basis than either other scheme. The insecticide scheme had 50% as many lady beetles as the strip-planted scheme, while the control scheme had 55% as many as the strip-planted. The preponderance of lady beetles in the strip-planted cotton was, as mentioned in relation to the Altus studies, most likely a result of the movement of these predators from the sorghum used in the interplanting scheme to the adjacent cotton, especially as the prey density in the sorghum declined.

Weekly average numbers of spiders per acre in each scheme are given in Table XVIII, p. 84. The general pattern of significant differences among schemes varies somewhat from that exhibited by numbers of Collops and lady beetles. At no time were spiders significantly more abundant in the strip-planted areas than in any other. There tended to be less distinction between the control and strip-planted schemes in regard to spiders than had existed with Collops and lady beetles. On an overall basis, no differences among schemes were significant. The insecticide treated areas had 90% as many spiders as did the strip-planted areas; the control had 92% as many. The insecticide scheme had more spiders relative to the strip-planted scheme than it had of any other predator group. This might indicate that spiders were less susceptible to the insecticides used in this study than were the other predators. Ridgway et al. (1967) reported that spiders were generally less affected by systemics than were other predator groups. Leigh et al. (1966) observed that spiders were often little affected by organophosphorus compounds. The insecticide dimethoate used for cotton fleahopper control in this study is a systemic as well as a contact poison and is an organophosphate. Both of the chemicals used for boll weevil control, azinphosmethyl and methyl parathion, are organophosphates. The use of these particular compounds may have somewhat favored the spiders over more susceptible groups.

Hooded flower beetles were the fourth most frequently encountered predators. Table XIX, p. 85, lists average numbers per acre of this insect. No scheme was particularly rich in these beetles. More were found in the control areas than elsewhere, but there were no significant differences overall. These beetles were important in the relative composition of the early season predator complex, especially in the control and insecticide schemes, as shown in Fig. 21, p. 116. On the first five sampling dates, 20% or more of the total predators in all schemes was composed of hooded flower beetles; on the fourth sampling (July 1), these beetles accounted for more than 50% of all the predators in both the control and insecticide schemes. They were present throughout the study, being most abundant on July 1 when 10,454 were estimated to be in the control areas, and least abundant September 1, when 109 per acre were estimated in both the insecticide and control areas.

The actual importance of hooded flower beetles as predators of cotton pests is not clearly established. Young (1969) mentioned the species Notoxus monodon F. as feeding on eggs, nymphs and larvae of destructive insects in cotton. However, van den Bosch and Hagen (1966) referred to hooded flower beetles only by remarking that _N. calcaratus_ Horn was known to feed on plant exudates and might also feed on small insects. Folsom (1936) had earlier described this species as a pest which fed on cotton squares. Orphanides et al. (1971) rated _N. calcaratus_ as a moderately efficient predator of lepidopteran eggs. Most reports of predatory insects in cotton do not mention hooded flower beetles, whereas all other predators included in this study are almost invariably included.

No green lacewing larvae or adults were detected during the first five sampling periods. Numbers throughout the remainder of the season were quite low, as shown in Table XX, p. 86. The lacewings were, as they had been at Altus, definitely late season predators. They made up not less than 20% of the total predators in all schemes on the final two observation dates (August 31 and September 7), but overall their contribution to the total predator comples was less than 5% in each scheme.

Lacewing eggs were found four weeks before any adults were encountered, indicating that sampling for adults was probably inadequate for accurate population estimation. At no time were differences among schemes significant in regard to numbers of lacewing eggs, as indicated in Table XXI, p. 87. Based on an overall average, the eggs:larvae ratio was 53.5:1. Possible reasons for apparent scarcity of adults were discussed in Chapter IV.

Table XXII, p. 88, lists estimated populations of big-eyed bugs and nabids each week. The levels were extremely low throughout the summer. Higher numbers of both were detected in the strip-planted areas, but overall differences among schemes were not significant.

Together the two genera made up less than 5% of the total predators in each scheme.

Figure 22, p. 117, illustrates the seasonal trends of the composite predatory community in each scheme. A similar pattern developed in each of the schemes, with the similarity most evident between the control and insecticide areas. The variation between the strip-planted areas and the others appears largely due to differences in lady beetle populations.

The first insecticide application (dimethoate at 0.1 pound AI per acre for cotton fleahopper control) was made July 10 to those plots which were designated to receive chemical control measures for insect pests. The slight decline in predators in the treated plots from the July 8 sampling to that of July 16 could be attributed to effects of the insecticide application. However, predator numbers in those plots had lagged below those in other plots, almost paralleling numbers in the control plots, prior to the initial insecticide application. Because a similar decline occurred in the control plots following the first insecticide application, it is perhaps questionable whether the spraying really had a marked effect on predator numbers in the target plots. If the insecticide did actually cause the predator decline in the treated plots, the similar decline in the control plots could have been caused by the effects of insecticide which drifted onto those plots. However, no corresponding decline occurred in the strip-planted plots; these should have been affected by insecticide drift if the control plots were. (Rows in the plots ran in an east-west direction. One strip-planted plot and one control plot were located immediately north of insecticide treated plots and would have seemed equally likely to receive insecticide drift carried by a predominantly south wind). During the period in question (July 8 to July 16), hooded flower beetle populations declined in all schemes. The noticeable decline in total predators in the insecticide treated areas was apparently largely the result of a decline in lady beetle populations in those areas. A decrease in the spider population could have been responsible for most of the decline in predators in the control plots.

On July 26 a second dimethoate application was made; the predator count three days later, on July 29, did not reflect a decrease. The two succeeding counts, on August 6 and 12, revealed marked decreases in predator numbers in all three schemes. These decreases may represent a delayed reaction to the insecticide in which the predators were relatively unharmed by contact action but were later destroyed by consuming poison prey. One would have to postulate considerable drift to both the strip-planted and control areas if the insecticide application is to be 'blamed' for the decline in the treated plots because similar declines occurred in these areas as well.

Much of the decline in all schemes could have been related to environmental factors other than the insecticide application. Throughout the entire month of July only 0.37 inch of rain fell on the experimental plots. Additionally, on each day from July 20 until July 28, the temperature exceeded 100^{o}F, contributing to an average monthly high of 99.7^{o}F. These hot, dry conditions may have been responsible for some measure of the declines shown in the predator counts of August 6. On August 10, 2.95 inches of rain fell on the experimental plots; this could have contributed to the decline in predators noted in all schemes from August 6 to August 12, by either direct effects on predators or indirect effects through destruction of prey. Normal population cycling may also have played a major role in the declines registered on both August 6 and 12.

Until August 12, the trends in predator numbers were quite similar, with the control and insecticide patterns being especially alike. As previously mentioned, the insecticide plots had fewer predators than the other areas prior to the first insecticide application. The fact that after the application there were fewer predators in the treated areas could, therefore, not be attributed wholly to the treatment itself. It seems likely that the promotion of larger predator populations in the more diversified habitat of the strip-planted scheme would better explain differences in predator totals among schemes than would the insecticide applications, at least until the sampling on August 12.

The decline in the number of predators in the insecticide treated areas on August 20 and the deviation of the predator trend in that scheme from trends in the other schemes may have resulted from the applications of azinphosmethyl for boll weevil control on August 14 and 19. Although the predators increased in both the control and strip-planted areas from August 12 to August 20, it is impossible to rule out the possibility that insecticide drift affected populations in these areas. An additional application of azinphosmethyl to the insecticide plots on August 22 perhaps contributed to a lower predator level there than in the other areas through the final sampling on September 7. Applications of methyl parathion were made to the insecticide plots on September 9 and 12 for boll weevil control. Effects of these on predator numbers were not ascertained because sampling was discontinued on September 7.

Cotton Fleahoppers

Average numbers of cotton fleahoppers per acre in the different schemes are given in Table XXIII, p. 89. Cotton fleahopper populations ranged from a low of 218 per acre in both the control and insecticide areas on the first sampling date, June 10, to a high of 20,255 per acre in the control areas on July 23. Infestations in the plots designated to receive chemical insect control measures were high enough on July 8 and July 23 to warrant treatment. Dimethoate at 0.1 pound AI per acre was applied to these plots on July 15 and 26. Significant differences in cotton fleahopper averages occurred among schemes on six sampling dates. Generally, the control areas had the highest numbers, with lowest numbers in the strip-planted areas early in the season and in the insecticide areas in the latter part of the season. On an overall basis, the control scheme had significantly more of these insects than the insecticide scheme; the strip-planted scheme was not different from either other. Cotton fleahoppers were less abundant in the strip-planted areas on nine of the 13 sampling dates. Although these differences were not statistically significant, they may indicate a greater measure of biological control in the strip-planted areas, which, as already discussed, had substantially more predators than the other areas.

Damage Caused by the *Heliothis* Complex

Table XXIV, p. 90, lists average numbers per acre of *Heliothis*-damaged fruits and the per cent of total fruits thus damaged in each scheme. Damage by *Heliothis* spp. was relatively insignificant during this study. At no time was the amount of damage sufficient to warrant treatment for Heliothis control. The greatest per cent damage detected on any sampling date was 2.33% in the insecticide plots on September 7. On that date, the insecticide plots had significantly more damage than the control plots; the damage in the strip-planted plots was not different from that in either other scheme. There were no significant differences in the overall amounts of damage sustained by the different schemes. Only 0.45%, 0.58% and 0.59% of the total fruit was damaged in control, strip-planted and insecticide schemes, respectively.

Heliothis spp. Larvae

Heliothis spp. larvae were counted during this study, but very few were encountered, as indicated in Table XXV, p. 91. No overall or weekly differences among schemes were significant. The season ratio of damaged fruits:larvae was 2.8:1. This is considerably lower than that reported by Quaintance and Brues (1905) of eight squares and 1.6 bolls per larva, but not much lower than data of Adkisson et al. (1964) which showed 3.8 damaged squares per larva in 1961.

Damage Caused by the Boll Weevil

The boll weevil was the most destructive pest encountered during the 1974 studies. Numbers of boll weevil-damaged fruits and the per cent of total fruits damaged by the weevil are given in Table XXVI, p. 92. Boll weevil damage was first observed on July 8. Through August 6, the amount of damage followed an almost parallel course in all schemes, as illustrated in Fig. 23, p. 118. The highest recorded number of damaged fruits was in the strip-planted scheme on September 7 when 31,254 fruits per acre showed weevil damage. The highest per cent of fruits damaged was 17.53%, also in the strip-planted scheme on September 7. Three insecticide applications were made for boll weevil control prior to the last sampling date: azinphosmethyl at 0.25 pound AI per acre on August 14 and 19, and at 0.50 pound AI per acre on August 22. Even with those applications the insecticide treated areas had significantly more weevil-damaged fruits than either control or strip-planted areas on August 31, the only date when there was a significant difference in damage among schemes. The insecticide scheme also sustained a somewhat larger per cent damage on an overall basis, having 4.33% damage, compared to 3.48% and 3.94% in the control and strip-planted schemes, respectively. The schemes were not significantly different in total numbers of damaged fruits.

Fruiting Characteristics

Average numbers per acre of squares, blooms and bolls are given in Tables XXVII, p. 93, XXVIII, p. 94, and XXIX, p. 95, respectively. The control and insecticide areas were consistently lower in square production than the strip-planted areas on the first seven sampling dates. However, during the second half of the observation period, the insecticide scheme produced more, often significantly more, squares than either the control or the strip-planted scheme. Overall, there were no significant differences among schemes in numbers of squares.

The strip-planted scheme led in bloom production early in the season, with blooms next most abundant in the insecticide plots, and least in the control. On the final five sampling dates, the insecticide plots had more blooms than either control or strip-planted plots. The insecticide plots produced significantly more blooms on an overall basis than the control plots ; strip-planted totals were not different from those of either other scheme.

The pattern of boll production did not show such a distinctive early lead by the strip-planted areas as had been demonstrated in square and bloom production. The general trend remained similar, with the insecticide plots again outproducing both other areas during the final weeks of the study. No significant differences in numbers of total bolls occurred among schemes.

Yield

Table XXX, p. 96, gives per plot and per acre yields of cotton as harvested with a mechanical stripper. Per plot yields were based on 12 rows of cotton in each plot. Each 12-row plot consisted of 2760 row feet. With 40-inch row spacing, there are 13,068 row feet per acre. Because 13,068/2760 = 4.7348, conversions to per acre yields were made by multiplying the per plot yields by 4.7348.

The average yield in the insecticide scheme exceeded that in the strip-planted scheme by five pounds per plot, or 26 pounds per acre. The average control yield was 87 and 82 pounds less per plot, or 413 and 387 pounds less per acre, than the insecticide and strip-planted yields, respectively. Variation in the control and strip-planted yields was particularly large. While some variation may have resulted from very localized field conditions, additional variation arose from problems encountered during the harvesting operation. Improper alignment of the stripper basket and the trailer used for transporting the cotton to the gin resulted in two especially noticeable losses and several smaller losses during the dumping operation from the basket into the trailer. Attempts were made to retrieve the cotton but a rather brisk wind made recovery difficult. Secondly, one of the trailers used to transport the cotton from the plots to the gin scales approximately five miles away was loaded almost to the top; consequently, various amounts of cotton were lost along the road each time this trailer was used. When dealing with yields from relatively small plots such as were used in this study, a small amount of loss can markedly affect results.

Analysis of yields on a randomized block basis indicated no significant differences at the 0.10 level of probability (Table XXXI, p. 97).

The grain sorghum rows in the strip-planted plots produced an average of 728 pounds of grain per plot, a rate equal to 5200 pounds per acre of solid-planted sorghum.

Effects of Transformation on Analysis of 1974 Data

In recent years a number of reports have indicated that various insects tend to be distributed in nature according to a negative binomial distribution pattern rather than being randomly distributed as in a Poisson series. The negative binomial distribution is described by two parameters: the mean and "k", the dispersion parameter or measure of the amount of clumping. The Poisson series, on the other hand, is essentially described by one parameter, because the variance equals the mean. Pieters and Sterling (1973) reported that observed frequency distributions of a number of cotton insects most often fit a negative binomial pattern.

Because an analysis of variance assumes a basically random distribution, application of such an analysis to data gathered from a population distributed according to a negative binomial series in which the variance is greater than the mean and varies disproportionately with the mean may be invalid. To overcome problems arising because of the negative binomial distributions, a number of data transformations have been suggested to stabilize variances and make the analysis of variance applicable. Two such transformations mentioned by Southwood (1966) are log (x + 1), where x = observed count, and log (x + k/2), where x = observed count and k = dispersion parameter of the negative binomial series.

To determine what practical effect data transformation would have on decisions regarding significance or non-significance of differences among field counts of cotton insects, spiders and fruit damage, three analyses of variance were performed on data collected during the 1974 growing season at Tipton, Oklahoma. Separate analyses of the different variables were made for each of 13 sampling periods based on (1) original data, (2) log (x + 1) transformed data, and (3) log (x + k/2) transformed data, with $k = \overline{x}^2 / s^2 - \overline{x}$.

Table XXXII, p. 98, indicates the differences in decisions made at various levels of probability when the analyses of transformed data are compared with those of original, untransformed data. At higher levels of probability, i.e., 0.01 and 0.05, very few differences were detected. As the probability level increased to 0.10 and 0.25, the number of differences increased, but, as shown in Table XXXIII, p. 98, never amounted to more than 10% of the total number of decisions. With both transformations, there were more instances when significant differences were declared which were not declared according to analysis of untransformed data than when significances were not declared which had been declared in the original analysis.

CHAPTER VII

SUMMARY AND CONCLUSIONS

During 1973 and 1974 cotton was grown in southwestern Oklahoma using three different insect control schemes: 1) strip-planted with grain sorghum, no insecticide applications, 2) solid-planted, with insecticide applications as recommended by the Oklahoma State University Agriculture Extension Service, and 3) solid-planted, with no insecticide applications (referred to as 'control'). The three schemes were compared on the bases of populations of predatory arthropods and cotton fleahoppers, fruiting characteristics, fruit damage and yield.

The 1973 studies utilized Westburn 70 cotton grown at Altus, Oklahome. Spiders made up the major group of predators, accounting for 64.8% of all predators in both the insecticide and strip-planted schemes and 68.1% in the control. Lady beetles were the second largest group, making up 12.7%, 13.0% and 13.9% of the total predators in the strip-planted, control and insecticide schemes, respectively. Green lacewings ranked third in abundance, accounting for 7.6%, 8.3% and 11.2% of the predators in the control, strip-planted and insecticide areas, respectively.

In 1974 on Thorpe cotton near Tipton, Oklahoma, no single group of predators was as dominant as spiders had been during the 1973 studies. Collops were most abundant, contributing an average of 29%, 26% and 25% of the predators in the strip-planted, control and insecticide schemes, respectively. Lady beetles were the second largest group, making up 29%, 23% and 21% of the predator totals in the strip-planted, insecticide and control areas, respectively. The third largest group was spiders, which made up 25% of the total in the insecticide plots, 23% in the control and 19% in the strip-planted.

During both years, the weekly predator total was usually highest in the strip-planted areas although differences among schemes were not always significant. Overall, predator numbers in the strip-planted scheme were higher both years at P = 0.10 than in either other scheme. In 1973, the control scheme had significantly more predators than the insecticide scheme, but in 1974 there was no difference between these two.

The cotton fleahopper was the primary early season pest both years. One insecticide application was made for control of this pest in 1973; two were made in 1974. The overall total of cotton fleahoppers was significantly greater each year in the control areas than in the insecticide treated areas. Totals in the strip-planted scheme were not different from those in the other schemes either year.

The major pest problem in 1973 was the *Heliothis* complex. One insecticide application was made for *Heliothis* control that year. The schemes were significantly different in the amount of *Heliothis*-damaged fruit only on July 31, when greatest damage was recorded in the insecticide treated areas. Overall, there were no significant differences among schemes in numbers of damaged fruits.

In 1974, the boll weevil was the most important pest. Five insecticide applications were made for boll weevil control. Only one weekly difference in numbers of weevil-damaged fruits was significant, that being on August 31 when greatest damage was recorded in the insecticide areas. There were no significant differences among schemes in overall numbers of weevil-damaged fruits.

In 1973, differences among schemes in numbers of squares, blooms and bolls were not significant. In 1974, the insecticide scheme produced significantly more blooms than the control scheme; the number of blooms in the strip-planted scheme was not different from that in either other scheme. There were no overall differences detected in square or boll production in 1974.

In 1973, the strip-planted areas produced significantly more cotton per acre than either control or insecticide areas. Per plot yields were not significantly different, but the strip-planted plots, with 96 rows of cotton each, had a greater average yield of cotton than plots in the other schemes, both of which had 116 rows of cotton per plot. Additionally, the strip-planted plots produced an average of 3450 pounds of grain sorghum each.

In 1974, there were no significant differences among yields of the three schemes. The insecticide and strip-planted yields were very similar and were higher than the control yield.

Taking into consideration predator numbers, fruit damage and yields, it appears that interplanting cotton with grain sorghum is a feasible alternative to at least some of the dependence on insecticides for cotton insect pest control in southwestern Oklahoma.

REFERENCES CITED

Adkisson, P.L. 1968. Development of resistance by the tobacco budworm to endrin and carbaryl. J. Econ. Entomol. 61:37-40.

Adkisson, P.L., R.L. Hanna and C.F. Bailey. 1964. Estimates of the numbers of *Heliothis* larvae per acre in cotton and their relation to the fruiting cycle and yield of the host. J. Econ. Entomol. 57:657-63.

Adkisson, P.L. and S.J. Nemec. 1967. Efficiency of certain insecticides for killing bollworms and tobacco budworms. Tex. Agr. Exp. Stn. PR 2357. 11 pp.

Allen, J., D. Gonzalez and D.V. Gokhale. 1972. Sequential sampling plans for the bollworm, *Heliothis zea*. Environ. Entomol. 1:771-80.

Bariola, L.A., R.L. Ridgway and J.R. Coppedge. 1971. Large-scale field test of soil applications of aldicarb for suppression of populations of boll weevils. J. Econ. Entomol. 64:1280-4.

Barnes, G., W. Boyer, J. Kimbrough, H. Sterling and M. Wall. 1973. Cotton Pest Management Program. Ark. Agr. Ext. Serv. Lfl. 52(rev). 12 pp.

Bell, K.O. and W.H. Whitcomb. 1962. Efficiency of egg predators of the bollworm. Ark. Farm Res. 11(6):9.

Bottrell, D.G., J.H. Young, R.G. Price and R.H. Adams. 1968. Parasites reared from *Heliothis* spp. in Oklahoma in 1965 and 1966. Ann. Entomol. Soc. Amer. 61:1053-5.

Brazzel, J.R. 1963. Resistance to DDT in *Heliothis virescens*. J. Econ. Entomol. 56:571-4.

Brazzel, J.R. 1964. Resistance to DDT in *Heliothis zea*. J. Econ. Entomol. 57:455-7.

Brazzel, J.R. 1965. Research for better insect control. Miss. Farm Res. 28(8):8.

Brazzel, J.R., L.D. Newsom, J.R. Roussel, C. Lincoln, F.J. Williams and G. Barnes. 1953. Bollworm and tobacco budworm as cotton pests in Louisiana and Arkansas. La. Agr. Exp. Stn. Tech. Bull. 482. 47 pp.

Brett, Charles H., R.R. Walton and E.E. Ivy. 1946. The cotton flea hopper, Psallus seriatus (Reut) in Oklahoma. Oklahoma Agr. and Mech. College Agr. Exp. Stn. Tech. Bull. T-24. pp. 5-31.

Bryan, D.E. 1961. Cotton insect control in Oklahoma. Okla. Agr. Exp. Stn. Pro. Ser. P-396. 14 pp.

Burke, H.R. 1959. Toxicity of several insecticides to two species of beneficial insects on cotton. J. Econ. Entomol. 52:616-8.

Burke, H.R. and D.F. Martin. 1956. The biology of three chrysopid predators of the cotton aphid. J. Econ. Entomol. 49:698-700.

Campbell, W.V. and R.E. Hutchins. 1952. Toxicity of insecticides to some predaceous insects of cotton. J. Econ. Entomol. 45:828-33.

Carter, F.L. and J.R. Phillips. 1968. Methyl parathion resistance in a laboratory strain of the bollworm. J. Econ. Entomol. 61:1716-8.

Coad, B.R. 1918. Recent experimental work on poisoning cotton-boll weevils. U.S. Dept. Agric. Bull. 731. 15 pp.

Coppock, Stanley. 1971. Worm pests of Oklahoma cotton. Okla. State Univ. Ext. Facts #7154. 2 pp.

DeLoach, C.J. and J.C. Peters. 1972. Effect of strip-planting vs solid-planting on predators of cotton insects in southeastern Missouri, 1969. Environ. Entomol. 1:94-101.

Eveleens, K.G., R. van den Bosch and L.E. Ehler. 1973. Secondary outbreak induction of beet armyworm by experimental insecticide applications in cotton in California. Environ. Entomol. 2:497-503.

Ewing, K.P. and E.E. Ivy. 1943. Some factors influencing bollworm populations and damage. J. Econ. Entomol. 36:602-6.

Ewing, K.P. and C.R. Parencia, Jr. 1949. Early-season application of insecticides for cotton insect control. USDA Bur. Entomol. and Plant Quar. E-792. 9 pp.

Fletcher, R.K. and F.L. Thomas. 1943. Natural control of eggs and first instar larvae of Heliothis armigera. J. Econ. Entomol. 557-60.

Folsom, J.W. 1928. Calcium arsenate as a cause of aphid infestation. J. Econ. Entomol. 21:174.

Folsom, J.W. 1936. Notes on little-known cotton insects. J. Econ. Entomol. 29:282-5.

Fye, R.E. and R.L. Carranza. 1972. Movement of insect predators from grain sorghum to cotton. Environ. Entomol. 1:790-1.

Fye, R.E. and D.J. Larsen. 1969. Preliminary evaluation of *Trichogramma minutum* as a released regulator of lepidopterous pests of cotton. J. Econ. Entomol. 62:1291-6.

Gaines, R.C. 1954. Effect on beneficial insects of several insecticides applied for cotton control. J. Econ. Entomol. 47:543-4.

Gast, R.T., F.E. Guthrie and J.D. Early. 1956. Laboratory studies in *Heliothis zea* (Boddie) and *H. virescens* (F.). J. Econ. Entomol. 49:408-9.

Glick, P.A. and W.B. Lattimore, Jr. 1954. The relation of insecticides to insect populations in cotton fields. J. Econ. Entomol. 47:681-4.

Graham, H.M. 1970. Parasitism of eggs of bollworms, tobacco budworms and loopers by *Trichogramma semifumatum* in the lower Rio Grande Valley, Texas. J. Econ. Entomol. 63:686-8.

Graves, J.B. and D.F. Clower. 1975. Status of resistance in *Heliothis* species. Proc. Beltwide Cotton Prod. Res. Conf. pp. 142-145.

Graves, J.B., D.F. Clower, J.L. Bagent and J.R. Bradley. 1964. Bollworms increasing in resistance to insecticides. La. Agr. 7(3):3, 16.

Graves, J.B., D.F. Clower, J.L. Bagent and J.R. Bradley, Jr. 1965. Seasonal occurrence of *Heliothis* larvae on cotton in Louisiana. J. Econ. Entomol. 58:1152-3.

Graves, J.B., D.F. Clower, D.R. Melville and L.W. Sloane. 1973. Tobacco budworm in Louisiana now resistant to methyl parathion. La. Agr. 16(4):10-11.

Graves, Jerry B., J.S. Roussel and J.R. Phillips. 1963. Resistance to some chlorinated hydrocarbon insecticides in the bollworm, *Heliothis zea*. J. Econ. Entomol. 56:442-4.

Hambleton, Edson J. 1944. *Heliothis virescens* as a pest of cotton with notes on host plants in Peru. J. Econ. Entomol. 37:660-6.

Hamner, A.L. 1941. Fruiting of cotton in relation to cotton fleahopper and other insects which do similar damage to squares. Miss. Agr. Exp. Stn. Bull. No. 360. 11 pp.

Hansen, M.H., W. Hurwitz and W. Madow. 1953. Sample Survey Methods and Theory. Vol. 1. J. Wiley and Sons, Inc. N.Y. 638 pp.

Harding, J.A., T.D. Dupnik, D.A. Wolfenbarger and T.W. Fuchs. 1975. Evaluation of plot size for arthropod studies in cotton. Tex. Agr. Exp. Stn. MP-1215. 2 pp.

Harris, F.A. 1970. Resistance of insects studied. Miss. Farm Res. 33(6):3.

Harris, F.A., J.B. Graves, S.J. Nemec, S.B. Vinson and D.A. Wolfenbarger. 1972. Insecticide resistance. In Distribution, Abundance and Control of Heliothis Species in Cotton and Other Host Plants. Southern Coop. Ser. Bull. No. 169:17-27.

Harries, F.H. and A.C. Valcarce. 1955. Laboratory tests of the effects of insecticides on some beneficial insects. J. Econ. Entomol. 48:614.

Hinds, W.E. 1908. The first and last essential step in combating the cotton boll weevil. J. Econ. Entomol. 1:233-43.

Hodges, J.W., R. Beshear and C. Beckham. 1966. Relative seasonal abundance of bollworm and tobacco budworm larvae on cotton in Georgia. J. Econ. Entomol. 59:128-31.

Howard, L.O. 1897. The Mexican cotton boll weevil (Anthonomus grandis Boheman). USDA Ent. Div. Cir. 18, 2nd series. 8 pp.

Hunter, W.D. and W.D. Pierce. 1912. The Mexican cotton-boll weevil. USDA Bur. Entomol. Bull. 114. 188 pp.

Isley, D. and W.J. Baerg. 1924. The boll weevil problem in Arkansas. Ark. Agr. Exp. Stn. Bull. 462. 29 pp.

Knapp, Seaman A. 1910. Cotton, the greatest of cash crops. USDA Office of the Secretary. Cir. No. 32. 10 pp.

Laster, M.L. and J.R. Brazzel. 1968. A comparison of predator populations in cotton under different control programs in Mississippi. J. Econ. Entomol. 61:714-9.

Leigh, T.F., V.E. Burton, J.H. Black and C.E. Jackson. 1966. Insecticides and beneficial insects in cotton fields. Calif. Agr. 20(7): 4-6.

Lewis, W.J. and J. Brazzel. 1968. A three-year study of parasites of the bollworm and the tobacco budworm in Mississippi. J. Econ. Entomol. 61:673-6.

Lincoln, Charles. 1972. Seasonal abundance. In Distribution, Abundance and Control of Heliothis Species in Cotton and Other Host Plants. Southern Coop. Ser. Bull. 169:2-7.

Lincoln, C. and T.F. Leigh. 1957. Timing insecticide applications for insect control. Ark. Agr. Exp. Stn. Bull. 588:1-47.

Lincoln, C., J.R. Phillips, W.H. Whitcomb, G.C. Dowell, W.P. Boyer, K.O. Bell, Jr., G.L. Dean, E.J. Matthews, J.B. Graves, L.D. Newsom, D.F. Clower, J.R. Bradley, Jr. and J.L. Bagent. 1967.

The bollworm-tobacco budworm problem in Arkansas and Louisiana. Ark. Agr. Exp. Stn. Bull. 720. 67 pp.

Lingren, P.D. 1969. Approaches to the management of Heliothis spp. in cotton with Trichogramma spp. In Proc. Tall Timbers Conf. on Ecol. Control by Habitat Mgmt. pp. 207-17.

Lingren, P.D. and D.E. Bryan. 1965. Dosage-mortality data on the tobacco budworm, Heliothis virescens, and the bollworm, Heliothis zea, in Oklahoma. J. Econ. Entomol. 58:14-8.

Lingren, P.D. and R.L. Ridgway. 1967. Toxicity of five insecticides to several insect predators. J. Econ. Entomol. 60:1639-41.

Lingren, P.D., R.L. Ridgway, C.B. Cowan, Jr., J.W. Davis and W.C. Watkins. 1968. Biological control of the bollworm and the tobacco budworm by arthropod predators affected by insecticides. J. Econ. Entomol. 6:1521-5.

Lopez, E.G. and G.L. Teetes. 1976. Selected predators of aphids in grain sorghum and their relation to cotton. J. Econ. Entomol. 69:198-204.

Lowry, W.L. 1966. Bollworm and tobacco budworm resistance to some insecticides in the lower Rio Grande Valley in 1964. J. Econ. Entomol. 59:479-80.

Lowry, W.L., R.L. McGarr, O.T. Robertson, R.S. Berger and H.M. Graham. 1965. Bollworm and tobacco budworm resistance to several insecticides in the lower Rio Grande Valley of Texas. J. Econ. Entomol. 58:732-4.

Marcovitch, S. 1935. Experimental evidence on the value of strip-farming as a method for the natural control of injurious insects with special reference to plant lice. J. Econ. Entomol. 28:62-70.

Massey, W.G., Jr. 1973. Effects on predator populations, insect damage, fruiting characteristics, and yield of cotton interplanted with corn and sorghum. Ph.D. dissertation. Oklahoma State University, Stillwater, Oklahoma. 81 pp.

Mistric, Jr., W.J., B.M. Covington and F.D. Smith. 1970. Effects of methyl parathion, DDT, and toxaphene on the boll weevil, bollworm, and cotton plant in North Carolina. J. Econ. Entomol. 63:596-9.

Neal, J.C. 1892. Station Notes--Insects. Oklahoma Agr. Exp. Stn. Bull. 3:3-20.

Newell, W. and R.C. Treherne. 1908. A new predaceous enemy of the cotton boll weevil. J. Econ. Entomol. 1:244.

Newsom, L.D. 1970. The end of an era and future prospects for insect control. In Proc. Tall Timbers Conf. on Ecol. Control by Habitat Mgmt. pp. 117-136.

Newsom, LD. and C.E. Smith. 1949. Destruction of certain insect predators by application of insecticides to control cotton pests. J. Econ. Entomol. 42:904-8.

Oklahoma Agriculture, 1973. 1974. Oklahoma Crop and Livestock Reporting Service. 128 pp.

Orphanides, G.M., D. Gonzales and B.R. Bartlett. 1971. Identification and evaluation of pink bollworm predators in southern California. J. Econ. Entomol. 64:421-4.

Parencia, C.R., Jr. and C.B. Cowen, Jr. 1960. Increased tolerance of the boll weevil and cotton fleahopper to some chlorinated hydrocarbon insecticides in Central Texas in 1958. J. Econ. Entomol. 53:52-6.

Pate, T.L. and J.R. Brazzel. 1964. Resistance of bollworms to poisons tested. Miss. Farm Res. 27(4):1-3.

Pickle, J.H., Jr. 1973. Augmentation of naturally occurring lepidopterous larvae and eggs as an attempt to control bollworm damage in cotton. Ph.D. dissertation. Oklahoma State University, Stillwater, Oklahoma. 102 pp.

Pierce, W.D. 1908. The economic bearing of recent studies of the parasites of the cotton boll weevil. J. Econ. Entomol. 1:117-20.

Pieters, E.P. and W.L. Sterling. 1973. Inferences on the dispersion of cotton arthropods in Texas. Environ. Entomol. 2:863-7.

Price, R.G., J.H. Young, B.G. Hill, S. Ratanabhumma, E. Johnson, K. Nualvatna and W. Ruth. 1975. A summary report on cotton insect research and control, 1974. 28th Annual Cotton Insect Res. and Cont. Conf. New Orleans, La., Jan. 6-8, 1975. p. 1.

Quaintance, A.L. and C.T. Brues. 1905. The cotton bollworm. USDA Bur. Entomol. Bull. 50. 155 pp.

Rechav, Y. 1974. Effects of common insecticides applied to cotton on adults of a Braconid parasitoid, Chelonus inanitus L. Environ. Entomol. 3:737-43.

Reinhard, H.J. 1926. The cotton fleahopper. Tex. Agr. Exp. Stn. Bull. 339. 39 pp.

Ridgway, R.L. and S.L. Jones. 1968a. Field-cage releases of Chrysopa carnea for suppression of populations of the bollworm and the tobacco budworm on cotton. J. Econ. Entomol. 61:892-8.

Ridgway, R.L. and S.L. Jones. 1968b. Plant feeding by Geocoris pallens and Nabis americoferus. Ann. Entomol. Soc. Amer. 6:232-3.

Ridgway, R.L. and P.D. Lingren. 1972. Predaceous and parasitic arthropods as regulators of Heliothis populations. In Distribution, Abundance and Control of Heliothis Species in Cotton and Other Host Plants. Southern Coop. Ser. Bull. 169:48-58.

Ridgway, R.L., P.D. Lingren, C.B. Cowan, Jr. and J.W. Davis. 1967. Populations of arthropod predators and Heliothis spp. after applications of systemic insecticides to cotton. J. Econ. Entomol. 60: 1012-6.

Robinson, R.R., J.H. Young and R.D. Morrison. 1972a. Strip-cropping effects on abundance of Heliothis-damaged cotton squares, boll placement, total bolls, and yields in Oklahoma. Environ. Entomol. 1:140-5.

Robinson, R.R., J.H. Young and R.D. Morrison. 1972b. Strip-cropping effects on abundance of predatory and harmful cotton insects in Oklahoma. Environ. Entomol. 1:145-9.

Roussel, John S. 1976. The "bollworms:" an up-date status report. Proc. 1976 Beltwide Cotton Prod.-Mech. Conf. and Special Sessions on Bollworm-Tobacco Budworm and Cotton Lint Contamination. pp. 50-54.

Roussel, J.S. and D. Clower. 1955. Resistance to the chlorinated hydrocarbon insecticides in the boll weevil (Anthonomus grandis Boh.). La. Agr. Exp. Stn. Circ. 41. 8 pp.

Rummel, D.R. and R.E. Reeves. 1971. Response of bollworm and predaceous arthropod populations to aldicarb treatments in cotton. J. Econ. Entomol. 64:907-11.

Sevacherian, V. and V.M. Stern. 1974. Host plant preferences of Lygus bugs in alfalfa-interplanted cotton fields. Environ. Entomol. 3:761-6.

Simon, J.E. 1954. Some experiments on the control of cotton pests: interplanted maize and systemic insecticides. Empire Cotton Grow. Rev. 33:246.

Smith, G.L. and J.A. Fontenot. 1942. Notes on the effects of arsenicals upon the cotton aphid, predators, and other insects. J. Econ. Entomol. 35:596.

Southwood, T.R.E. 1966. Ecological Methods. Chapman and Hall, London. 391 pp.

Stern, V.M., A. Mueller, V. Sevacherian and M. Way. 1969. Lygus bug control in cotton through alfalfa interplanting. Calif. Agr. 23 (2):8-10.

Stoner, Adair. 1970. Plant feeding by a predaceous insect, Geocoris punctipes. J. Econ. Entomol. 63:1911-5.

Stoner, Adair. 1972. Plant feeding by Nabis, a predaceous genus. Environ. Entomol. 1:557-8.

Timmons, F.D., T.S. Brook and F.A. Harris. 1973. Effects of aldicarb applied side-dress to cotton on some arthropods in the Monroe County, Mississippi, boll weevil diapause-control area in 1969. J. Econ. Entomol. 66:151-3.

Twenty-ninth Annual Conference Report on Cotton Insect Research and Control. Jan. 5-7, 1976. Las Vegas, Nevada. pp. 24-28.

van den Bosch, R. 1971. The melancholy addiction of ol' king cotton. Nat. Hist. 80(10):86-91.

van den Bosch, R. and K. Hagen. 1966. Predaceous and parasitic arthropods in California cotton fields. Calif. Agr. Exp. Stn. Bull. 820. 32 pp.

van den Bosch, R., T.F. Leigh, D. Gonzales and R.E. Stinner. 1969. Studies on predators of the bollworm in cotton. J. Econ. Entomol. 62:1486-9.

van den Bosch, R. H.T. Reynolds and E.J. Dietrick. 1956. Toxicity of widely used insecticides to beneficial insects in California cotton and alfalfa fields. J. Econ. Entomol. 49:359-63.

Walker, J.K., Jr. and G.A. Niles. 1971. Population dynamics of the boll weevil and modified cotton types. Tex. Agr. Exp. Stn. Bull. 1109. 14 pp.

Walker, J.K., Jr., Merle Shepard and W.L. Sterling. 1970. Effect of insecticide applications for the cotton fleahopper on beneficial insects and spiders. Tex. Agr. Exp. Stn. PR-2755. 11 pp.

Watson, T.F. and M.C. Sconyers. 1965. Comparison of insecticide application schedules for control of cotton insects. J. Econ. Entomol. 58:1124-7.

Whitcomb, W.H. and K. Bell. 1964. Predaceous insects, spiders, and mites of Arkansas cotton fields. Ark. Agr. Exp. Stn. Bull. 690. 84 pp.

Wille, J.E. 1951. Biological control of certain cotton insects and the application of new organic insecticides in Peru. J. Econ. Entomol. 44:13-18.

Wolfenbarger, D.A. and R.L. McGarr. 1970. Toxicity of methyl parathion, parathion, and monocrotophos applied topically to lepidopteran pests of cotton. J. Econ. Entomol. 63:1762-4.

Young, D.F., Jr. 1969. Cotton Insect Control. Oxmoor Press, Birmingham, Alabama. 185 pp.

Young, J.H. and R.G. Price. 1970. Irrigation research report, 1970. Oklahoma State University Agr. Exp. Stn. Progress Rept. P-639: 8-10.

Young, J.H. and R.G. Price. 1975. Incidence, parasitism, and distribution patterns of Heliothis zea on sorghum, cotton, and alfalfa for southwestern Oklahoma. Environ. Entomol. 4:777-9.

Young, J., R. Price, S. Coppock, E. Cleveland, J. Coakley and B. Hines. 1973. 1973 Cotton insect control in Oklahoma. Oklahoma State University Ext. Facts No. 7162. 2 pp.

Young, J., R. Price, J. Coakley, E. Cleveland, J. Pickle and K. Pinkston. 1974. 1974 Cotton insect control in Oklahoma. Oklahoma State University Ext. Facts No. 7162. 2 pp.

Young, J.H., R.G. Price, Jerry Coakley and E. Johnson. 1976. A summary report on cotton insect research and control, 1975. 29th Annual Cotton Insect Res. and Control Conf. Las Vegas, Nevada. Jan. 5-8, 1976. pp. 14-15.

APPENDIX

TABLE I

AVERAGE NUMBERS OF PREDATORY ARTHROPODS PER ACRE ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Scheme		
	Insecticide	Control	Strip
June 26	655	778	1184
July 3	6285	7164	14409
July 10	14011a	15730a	22305
July 17	11784	23205	28424
July 25	16237a	25074b	33952c
July 31	19379	26320	30004
August 7	1048	11680a	10855a
August 14	4060	10435	12633
August 21	8380	14794	15593
August 31	9036	11262	15002
Overall total	90875a	146442b	184361c

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE II

AVERAGE NUMBERS OF SPIDERS PER ACRE ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Scheme		
	Insecticide	Control	Strip
June 26	524	467	197
July 3	4714	5762	7896
July 10	9297	10902	10264
July 17	7856	15263	19936
July 25	8642a	12771a	23687
July 31	13225	20714	18950
August 7	786	8566	8093
August 14	2881	7164	10462
August 21	5761	10123	9277
August 31	5238	7977	10659
Overall total	58924	99709a	119421a

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE III

AVERAGE NUMBERS OF LADY BEETLES PER ACRE ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Scheme		
	Insecticide	Control	Strip
June 26	0	311	790
July 3	1440a	779a	4145
July 10	2619a	2959a	7303
July 17	1964	4672	3948
July 25	3797	7008	4343
July 31	1440	2803	2369
August 7	131	467	0
August 14	393	779	0
August 21	0	311	592
August 31	0	313	0
Overall total	11784	20402a	23490a

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE IV

AVERAGE NUMBERS PER ACRE OF GREEN LACEWING LARVAE AND ADULTS ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Larvae			Adults		
	Insecticide	Control	Strip	Insecticide	Control	Strip
July 17	0	156	0	0	311	0
July 25	1964	311	0	262	0	395
July 31	1571	623	2369	655	156	1184
August 7	0	1402	1184	0	311	592
August 14	524	1402	987	262	779	395
August 21	1309	2803	3158	131	311	987
August 31	2750	2190	3356	786	313	592
Overall total	8118	8887	11054	2096a	2181ab	4145b

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE V

AVERAGE NUMBERS PER ACRE OF GREEN LACEWING EGGS ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Scheme		
	Insecticide	Control	Strip
July 3	131	0	0
July 10	393	623	197
July 17	4059a	9500b	5922ab
July 25	17546a	23517b	34741c
July 31	15713	22271	23884
August 7	16629	50304	38096
August 14	37111	55911	76982
August 21	45174	76781	70271
August 31	3143	48489	60007
Overall total	140498	287499	310101

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE VI

AVERAGE NUMBERS PER ACRE OF BIG-EYED BUGS AND NABIDS ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Big-Eyed Bugs			Nabids		
	Insecticide	Control	Strip	Insecticide	Control	Strip
June 26	0	0	197	131	0	0
July 3	0	467	1184	131	156	1184
July 10	1178	467	1974	655	1402	2369
July 17	262a	467a	2566	1309	2180	1184
July 25	524	623	987	655a	1869ab	3158b
July 31	786	311	395	1309	1713	1579
August 7	0	0	0	0	623	197
August 14	0	311	0	0	0	592
August 21	131	0	197	131	0	0
August 31	0	0	0	262	469	0
Overall total	2881	2646	7500	4583	8412	10263

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE VII

AVERAGE NUMBERS PER ACRE OF COLLOPS AND HOODED FLOWER BEETLES ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Collops			Hooded Flower Beetles		
	Insecticide	Control	Strip	Insecticide	Control	Strip
July 10	131	0	395	131	0	0
July 17	0	0	790	393	156	0
July 25	393	1869	790	0	623	592
July 31	393a	0a	1579	0a	0a	1579
August 7	131	311	592	0	0	197
August 14	0	0	197	0	0	0
August 21	917	1246	1382	0	0	0
August 31	0	0	395	0	0	0
Overall total	1956	3426	6120	524	779	2368

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE VIII

AVERAGE NUMBERS OF COTTON FLEAHOPPERS PER ACRE ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Scheme		
	Insecticide	Control	Strip
June 26	262	1090	592
July 3	3928	5607	7106
July 10	12308	11992	7896
July 17	786	4984a	6317a
July 25	5499	10590	10659
July 31	4976	4672	2369
August 7	393a	4205b	1777ab
August 14	0	623a	592a
August 21	655	1090	197
August 31	655	938	197
Overall total	29462a	45791b	37702ab

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE IX

AVERAGE NUMBERS PER ACRE OF HELIOTHIS-DAMAGED FRUITS AND PER CENT TOTAL FRUITS DAMAGED ON WESTBURN 70 COTTON, ALTUS, OKLAHOMA, 1973[a]

Date	Heliothis-Damaged Fruits			Per Cent Total Fruits Damaged		
	Insecticide	Control	Strip	Insecticide	Control	Strip
July 17	0	156	0	0	0.13	0
July 25	11261	5607	2763	3.37	2.00	0.78
July 31	29985	4517a	2566a	6.43	0.98	0.70
August 7	13880	11058	17568	2.41	1.71	2.56
August 14	15713	33640	40860	1.80	5.25	4.32
August 21	38889	31927	35136	4.56	3.47	4.34
August 31	32604	30032	23490	5.64	3.66	2.69
Overall total	142332	116806	122383	3.70	2.95	2.87

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE X

AVERAGE NUMBERS IN THOUSANDS OF SQUARES PER ACRE ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Scheme		
	Insecticide	Control	Strip
June 26	0.13	0.00	0.00
July 3	2.88	4.98	1.78
July 10	46.74a	55.91ab	61.39b
July 17	122.04a	124.44a	165.02
July 25	333.11b	279.56a	351.16c
July 31	452.40a	444.80a	344.05
August 7	545.63	610.66	637.97
August 14	769.92a	544.00	821.34a
August 21	667.92	734.16	598.49
August 31	269.74	461.11	431.10
Overall total	3210.51	3260.60	3412.29

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XI

AVERAGE NUMBERS IN THOUSANDS OF BLOOMS PER ACRE ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Scheme: Insecticide	Control	Strip
July 25	2.75	1.87	2.57
July 31	6.15	2.96	12.04
August 7	7.72	12.15a	11.84a
August 14	29.98	30.37	35.92
August 21	39.54	39.40	50.34
August 31	43.47	53.65	44.81
Overall total	129.63	140.32	157.72

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XII

AVERAGE NUMBERS IN THOUSANDS OF BOLLS PER ACRE ON WESTBURN 70 COTTON BY SCHEME AND DATE, ALTUS, OKLAHOMA, 1973[a]

Date	Scheme		
	Insecticide	Control	Strip
July 25	0.79	1.09	1.38
July 31	13.88	18.22	21.32
August 7	29.99	35.04	49.35
August 14	102.26	96.72	123.76
August 21	185.02a	187.20a	210.42
August 31	308.76	358.66	442.35
Overall total	640.69	696.79	848.58

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XIII

POUNDS OF STRIPPER HARVESTED WESTBURN 70 COTTON BY SCHEME, PER PLOT AND PER ACRE, ALTUS, OKLAHOMA, 1973[a]

Scheme	Yield Per Plot*			Yield Per Acre		
	Block 1	Block 2	Average	Block 1	Block 2	Average
Insecticide	9,940	9,790	9,865	2,635	2,595	2,615a
Control	11,930	8,750	10,340	3,162	2,319	2,741a
Strip-Planted	11,440	13,000	12,220**	3,664	4,164	3,914

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability.

*Yields in insecticide and control schemes based on 116 rows of cotton per plot; yields in strip-planted scheme based on 96 rows of cotton per plot.

**Additionally, strip-planted plots produced an average of 3450 pounds of grain sorghum per plot.

TABLE XIV

ANALYSIS OF VARIANCE OF YIELD ON PER ACRE BASIS, WESTBURN 70 COTTON, ALTUS, OKLAHOMA, 1973

Source	DF	SS	MS	F
Total	5	2,534,627		
Schemes	2	2,053,500	1,026,750	6.402
Error	3	481,127	160,375	

Required F for Schemes at P = 0.10: 5.46

TABLE XV

AVERAGE NUMBERS PER ACRE OF PREDATORY ARTHROPODS ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
June 10	2723	3377	2614
June 17	9148	7079	7842
June 24	13613a	14594a	21454
July 1	16989a	18730a	26354
July 8	21563	23088	21998
July 16	20256a	21890a	32017
July 23	30602a	35720ab	73778b
July 29	36373a	43779a	66757
August 6	21562a	26463ab	34739b
August 12	11870	8169	11653
August 20	6862a	16010ab	25809b
August 31	11000a	12633a	15901
September 7	4573	11761a	11652a
Overall total	207134a	243293a	322568

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XVI

AVERAGE NUMBERS PER ACRE OF COLLOPS ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
June 10	109	0	0
June 17	109	0	109
June 24	327	218	545
July 1	545	653	1525
July 8	4792	4683	5445
July 16	8385a	10346ab	15355b
July 23	11543	13395	16880
July 29	19275a	23958a	36264
August 6	4683a	7514a	13721
August 12	871	545	871
August 20	327a	1525ab	2940b
August 31	545	545	1089
September 7	0	218	0
Overall total	51511a	63600a	94744

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XVII

AVERAGE NUMBERS PER ACRE OF LADY BEETLES ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
June 10	1525	1634	1089
June 17	3267	1960	2723
June 24	4356a	4901a	10999
July 1	3594a	3376a	11870
July 8	6861	4901	6861
July 16	4792a	4792a	8168
July 23	8168	8494	13068
July 29	6207a	7079a	17424
August 6	4465a	5118a	10999
August 12	2069	2287	2396
August 20	871	3703a	5336a
August 31	762a	2069b	1634ab
September 7	653	1198	1742
Overall total	47590a	51512a	94309

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XVIII

AVERAGE NUMBERS PER ACRE OF SPIDERS ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
June 10	218	545	436
June 17	1198	2396a	2396a
June 24	3485	3267	4029
July 1	3049	3485	4029
July 8	3376a	5554	3594a
July 16	4138ab	2723a	5118b
July 23	5118	5772	5009
July 29	7950	5990	7732
August 6	7187	8712	6316
August 12	5118	3267	5445
August 20	3158	5881a	6861a
August 31	3920	4901	5990
September 7	2831	3920	4574
Overall total	50746	56413	61529

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XIX

AVERAGE NUMBERS PER ACRE OF HOODED FLOWER BEETLES ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
June 10	871	1089	980
June 17	4574	2178a	2287a
June 24	5118	5772	5445
July 1	8821	10454	7950
July 8	4683	6643	4465
July 16	1851	2287	1198
July 23	3812	6316	4792
July 29	1198	4683	3594
August 6	3267	3812	1960
August 12	2287	1089	1198
August 20	762a	3376ab	7623b
August 31	1525	1960	2396
September 7	109a	109a	653
Overall total	33878	49768	44541

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XX

AVERAGE NUMBERS PER ACRE OF GREEN LACEWING LARVAE AND ADULTS ON THORPE COTTON, TIPTON, OKLAHOMA, 1974[a]

Date	Larvae			Adults		
	Insecticide	Control	Strip	Insecticide	Control	Strip
July 16	0	0	0	436	0	0
July 23	436	327	109	327	436	1851
July 29	218	109	0	327	0	218
August 6	0	0	0	436	109	545
August 12	436	327	109	762	327a	327a
August 20	327	218	653	545	653	1198
August 31	109a	871	0a	3594	2287	4247
September 7	0	1742	1198	980	4356	3267
Overall total	1526	3594	2069	7407	8168	11762

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XXI

AVERAGE NUMBERS PER ACRE OF GREEN LACEWING EGGS ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme Insecticide	 Control	 Strip
June 17	109	0	436
June 24	109	109	0
July 1	218	0	109
July 8	653	0	1089
July 16	436	327	327
July 23	5009	3485	3703
July 29	6861	5336	11543
August 6	14266	8168	9257
August 12	9039	7405	7514
August 20	23740	22978	25483
August 31	32452	33106	26463
September 7	37135	45956	41600
Overall total	130027	126870	127524

[a]No significant differences among schemes within dates were indicated at the 0.10 level of probability.

TABLE XXII

AVERAGE NUMBERS PER ACRE OF BIG-EYED BUGS AND NABIDS ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Big-Eyed Bugs			Nabids		
	Insecticide	Control	Strip	Insecticide	Control	Strip
June 10	0	109	109	0	0	0
June 17	0	327	218	0	218	109
June 24	218	327	218	109	109	218
July 1	109	0	218	871	762	762
July 8	762	762	653	1089	545	980
July 16	436	871	653	218a	871a	1416
July 23	871	871	1307	327	109	762
July 29	436	762	545	762	1198	980
August 6	871	545	871	653	653	327
August 12	109	218	327	218a	109a	980
August 20	436	436	871	1136	218	327
August 31	545b	0a	218ab	0	0	327
September 7	0	218	109	0	0	109
Overall total	4793	5228	6099	4683	5010	7515

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XXIII

AVERAGE NUMBERS PER ACRE OF COTTON FLEAHOPPERS ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
June 10	218	218	327
June 17	3594	3267	2505
June 24	7841	8059	6425
July 1	7841	7079	7514
July 8	16117	13068	12306
July 16	4029a	13068	6752a
July 23	14266	20255	18731
July 29	6861	15355a	15464a
August 6	4465a	14157c	8603b
August 12	4901	5445	6970
August 20	2723a	7950b	5772ab
August 31	2614a	6316b	4029ab
September 7	871a	4356	1416a
Overall total	76341a	118593b	96814ab

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XXIV

AVERAGE NUMBERS PER ACRE OF HELIOTHIS-DAMAGED FRUITS AND PER CENT TOTAL FRUITS DAMAGED ON THORPE COTTON, TIPTON, OKLAHOMA, 1974[a]

Date	Heliothis-Damaged Fruits			Per Cent Total Fruits Damaged		
	Insecticide	Control	Strip	Insecticide	Control	Strip
July 8	0	307	218	0.00	0.32	0.17
July 16	218ab	109a	436b	0.07	0.26	0.14
July 23	1416	1307	1851	0.74	0.69	0.62
July 29	436	1089	1416	0.25	0.83	0.79
August 6	871	436	980	0.40	0.32	0.62
August 12	1198	218	327	0.51	0.15	0.22
August 20	871	327	545	0.40	0.19	0.28
August 31	1198	653	1525	0.46	0.39	0.74
September 7	5009b	2178a	3158ab	2.33	1.28	1.77
Overall total	11217	6644	10456	0.59	0.45	0.58

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XXV

AVERAGE NUMBERS PER ACRE OF *HELIOTHIS* LARVAE ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
July 16	109	0	327
July 23	219	436	653
July 29	109	0	219
August 6	109	0	0
August 12	327	0	109
August 20	109	109	109
August 31	871	109	980
September 7	2396	1307	1416
Overall total	4249	1961	3813

[a]No significant differences among schemes within dates were indicated at the 0.10 level of probability.

TABLE XXVI

AVERAGE NUMBERS PER ACRE OF BOLL WEEVIL-DAMAGED FRUITS AND PER CENT TOTAL FRUITS DAMAGED ON THORPE COTTON, TIPTON, OKLAHOMA, 1974[a]

Date	Boll Weevil-Damaged Fruits			Per Cent Total Fruits Damaged		
	Insecticide	Control	Strip	Insecticide	Control	Strip
July 8	0	218	436	0.00	0.21	0.34
July 16	545	218	1089	0.14	0.65	0.35
July 23	2614	1525	3485	1.36	0.80	1.16
July 29	2505	1851	3049	1.43	1.40	1.71
August 6	3049	545	3594	1.40	0.39	2.26
August 12	7841	1851	3049	3.32	1.30	2.02
August 20	9583	3703	10890	4.41	2.19	5.62
August 31	26898	13395a	14702a	10.25	7.98	7.14
September 7	29076	28641	31254	13.53	16.82	17.53
Overall total	82111	51947	71548	4.33	3.48	3.94

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XXVII

AVERAGE NUMBERS IN THOUSANDS OF SQUARES PER ACRE ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
June 10	0.11	0.11	0.98
June 17	11.00	10.78	15.14
June 24	32.78	37.03	47.59
July 1	62.18	72.20	93.22
July 8	114.34	99.75	120.34
July 16	135.14	137.76	142.12
July 23	150.17	145.82	226.08
July 29	122.30	85.70	109.34
August 6	119.14	53.69a	60.22a
August 12	141.57	72.25a	55.87a
August 20	121.64b	93.98ab	80.70a
August 31	121.64	89.08	109.99
September 7	74.45	73.62	68.61
Overall total	1206.50	974.76	1130.16

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XXVIII

AVERAGE NUMBERS IN THOUSANDS OF BLOOMS PER ACRE ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme: Insecticide	Scheme: Control	Scheme: Strip
July 1	0.00	0.11	0.00
July 8	4.46	3.16	3.16
July 16	7.95	6.75	9.26
July 23	4.36	4.25	5.44
July 29	8.82	7.30	10.89
August 6	9.26	5.01	8.17
August 12	6.64b	2.29a	3.28ab
August 20	2.94	1.09	1.42
August 31	5.66b	1.20a	1.85ab
September 7	5.44	2.29	2.40
Overall total	55.54b	33.43a	45.96ab

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XXIX

AVERAGE NUMBERS IN THOUSANDS OF BOLLS PER ACRE ON THORPE COTTON BY SCHEME AND DATE, TIPTON, OKLAHOMA, 1974[a]

Date	Scheme		
	Insecticide	Control	Strip
July 8	2.94	3.27	2.07
July 16	21.13	20.04	25.92
July 23	41.71	44.10	74.81
July 29	53.25	46.06	69.15
August 6	99.43	84.72	98.34
August 12	94.63	66.65	94.74
August 20	95.83	75.47	113.15
August 31	140.70b	78.84a	96.05ab
September 7	140.37	96.70	109.66
Overall total	689.99	515.86	683.89

[a]Means followed by the same letter are not significantly different by LSD at the 0.10 level of probability. Contrasts among schemes were made within dates.

TABLE XXX

POUNDS OF STRIPPER HARVESTED THORPE COTTON
BY SCHEME, PER PLOT AND PER ACRE,
TIPTON, OKLAHOMA, 1974[a]

Block	Yield Per Plot*			Yield Per Acre		
	Insecticide	Control	Strip	Insecticide	Control	Strip
1	358	314	301	1697	1486	1424
2	225	63	154	1066	297	730
3	234	102	401	1109	484	1895
4	367	358	308	1739	1693	1459
Average	296	209	291	1403	990	1377

[a]Scheme averages were not significantly different at P = 0.10 on either a 'Per Plot' or a 'Per Acre' basis.

*12 rows, each 230 feet long, were harvested per plot.

TABLE XXXI

ANALYSIS OF VARIANCE OF YIELD ON PER PLOT BASIS,
THORPE COTTON, TIPTON, OKLAHOMA, 1974

Source	DF	SS	MS	F
Total	11	133,997		
Blocks	3	72,098	24,032	3.359
Schemes	2	18,978	9489	1.326
Error	6	42,921	7154	

Required F for Blocks at P = 0.10: 3.29

Required F for Schemes at P = 0.10: 3.46

TABLE XXXII

NUMBER OF DIFFERENCES FROM 120 DECISIONS
BASED ON AOV OF UNTRANSFORMED DATA

Level of Probability	Transformation			
	Log (x + 1)		Log (x + k/2)	
	+*	-**	+*	-**
0.01	3	1	3	1
0.05	1	2	2	2
0.10	6	1	6	3
0.25	5	6	6	4

*Significance declared when not declared on original data

**Significance not declared when declared on original data

TABLE XXXIII

TOTAL PER CENT OF DECISIONS ALTERED WHEN ANALYSIS OF
UNTRANSFORMED DATA IS COMPARED WITH THAT
OF TRANSFORMED DATA

Level of Probability	Transformation	
	Log (x + 1)	Log (x + k/2)
0.01	3.33%	3.33%
0.05	2.50%	3.33%
0.10	5.83%	7.50%
0.25	9.17%	8.33%

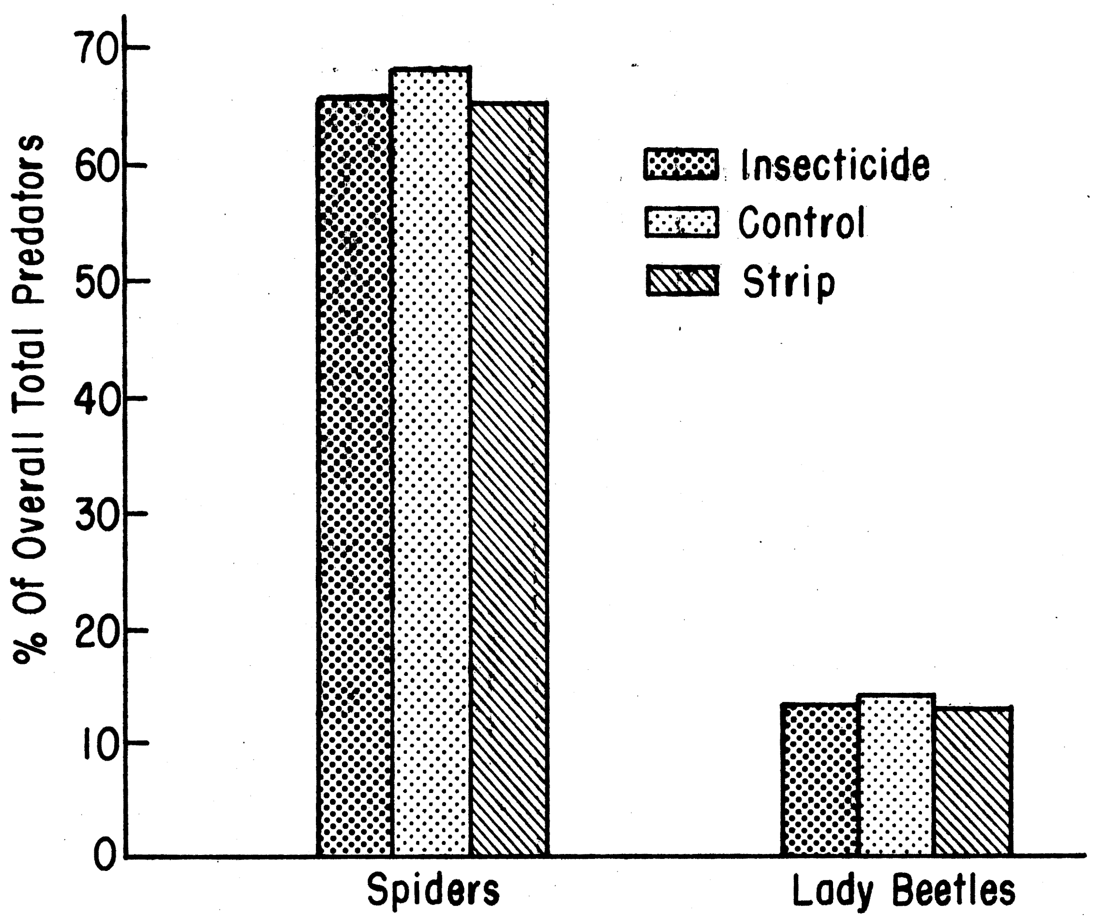

Figure 1. Percentages of Overall Total Predators Composed of Spiders and Lady Beetles, Westburn 70 Cotton, Altus, Oklahoma, 1973

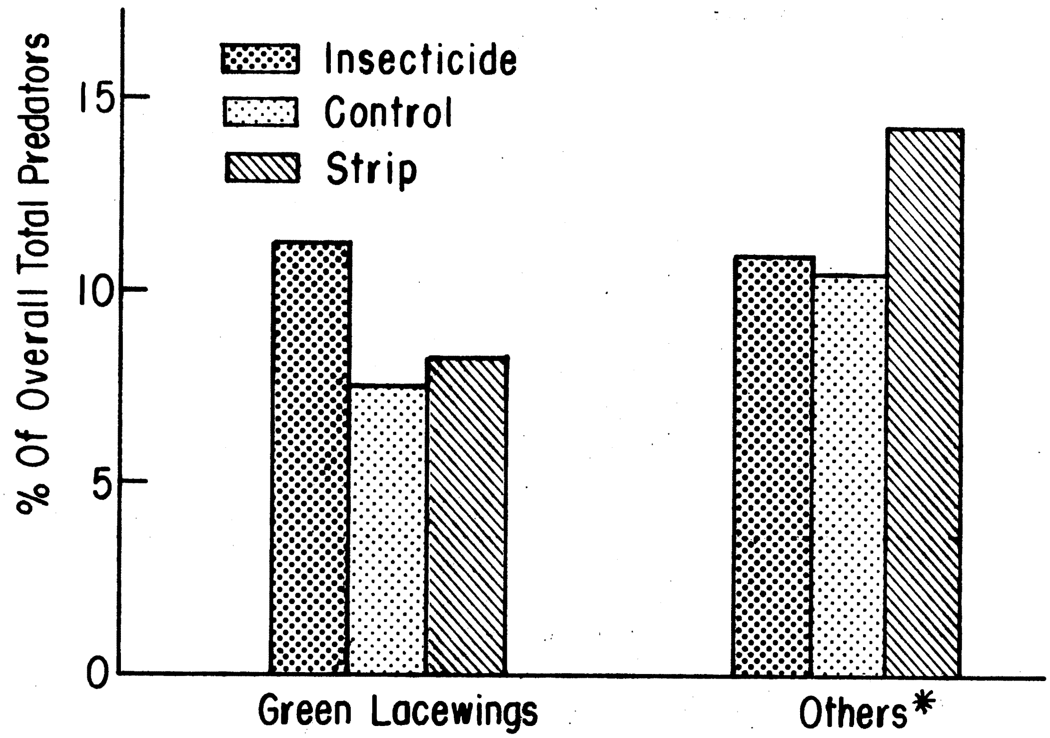

Figure 2. Percentages of Overall Total Predators Composed of Green Lacewings and Other Less Abundant Predators, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Big-eyed Bugs, Collops, Hooded Flower Beetles, Nabids)

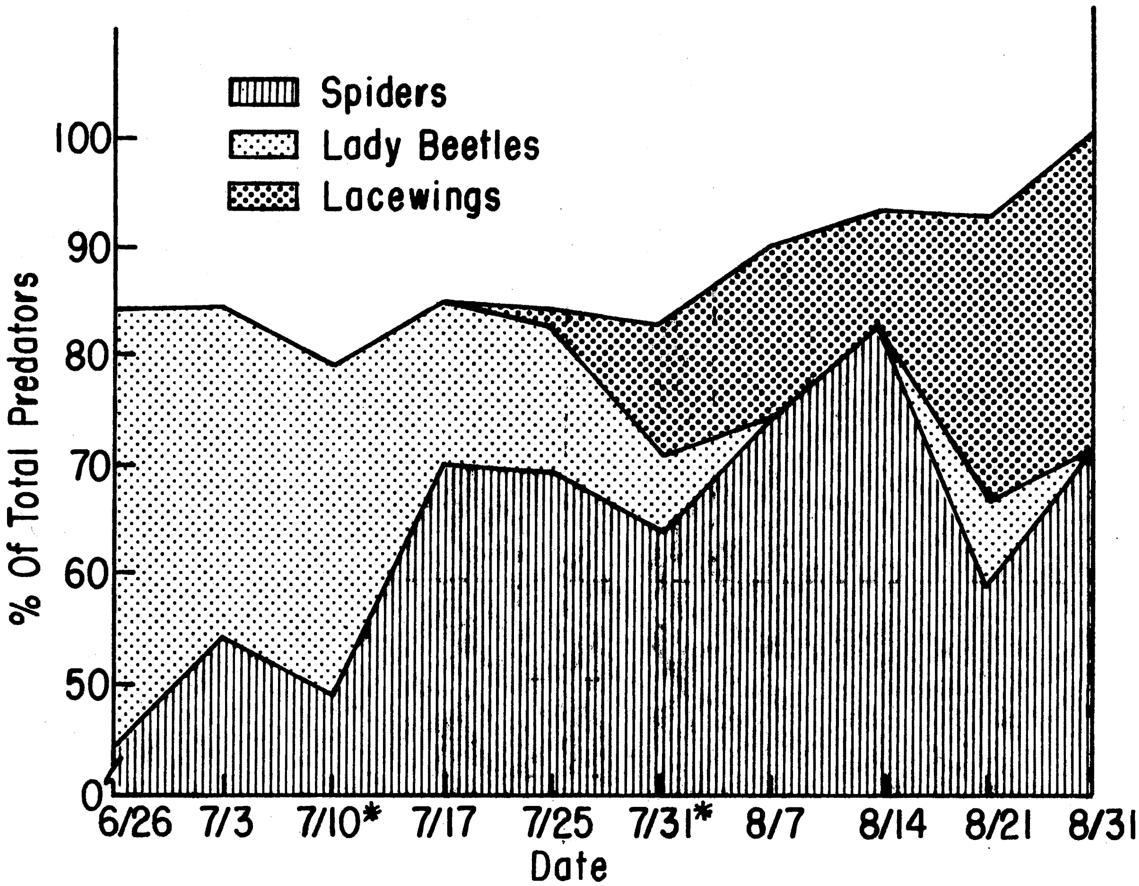

Figure 3. Relative Importance of Major Predators in Strip-Planted Scheme, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

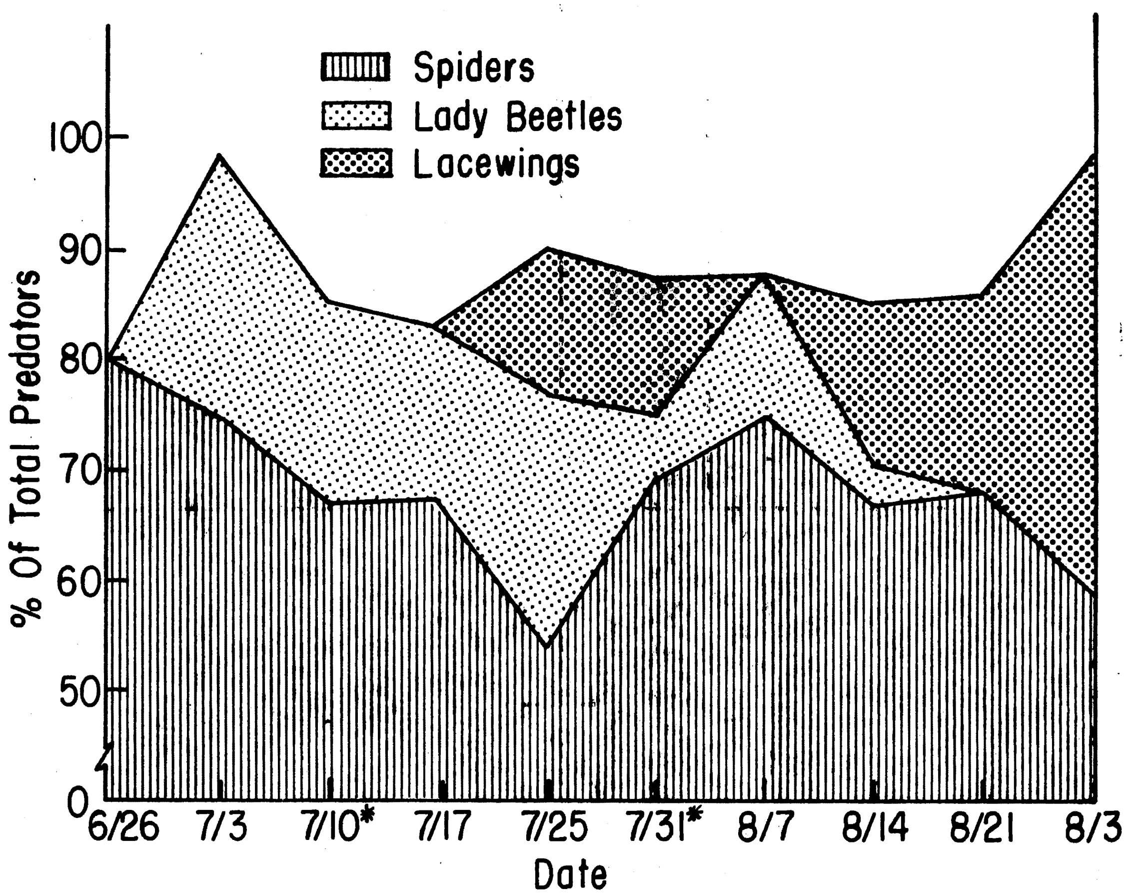

Figure 4. Relative Importance of Major Predators in Insecticide Scheme, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

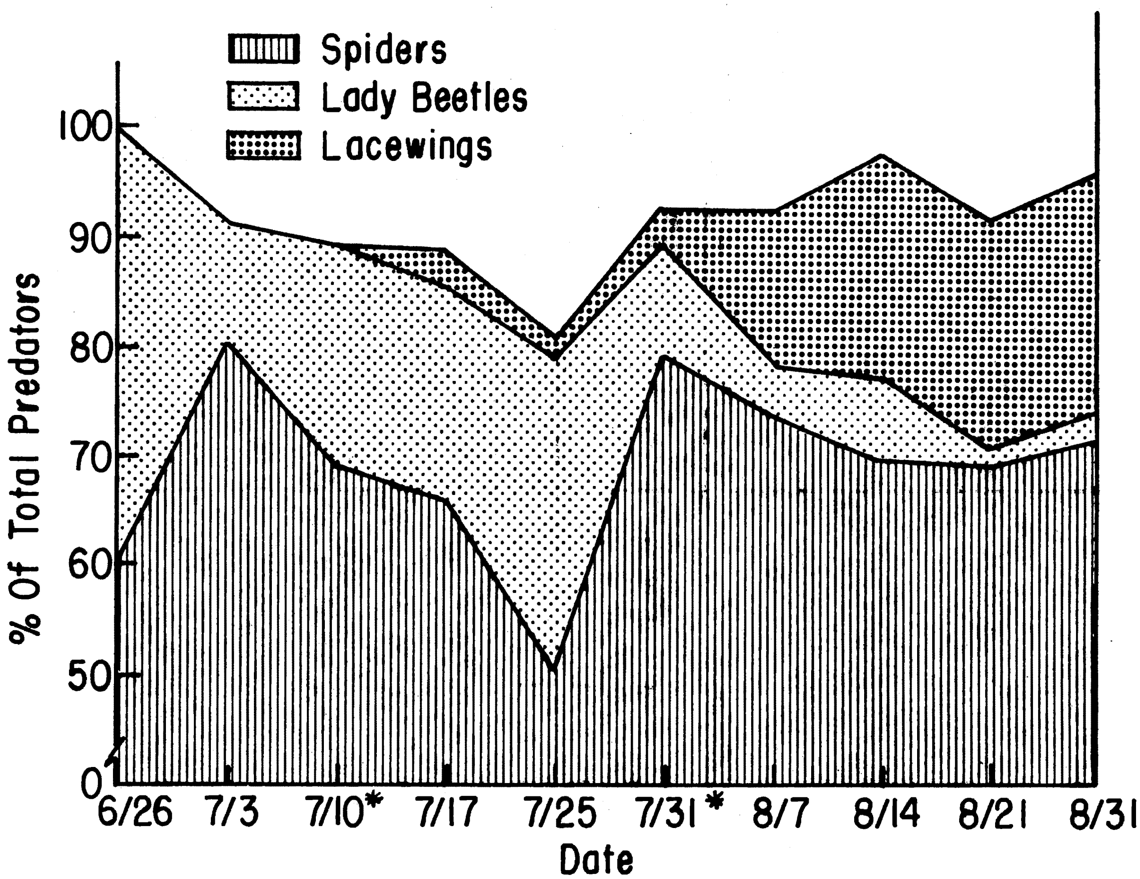

Figure 5. Relative Importance of Major Predators in Control Scheme, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

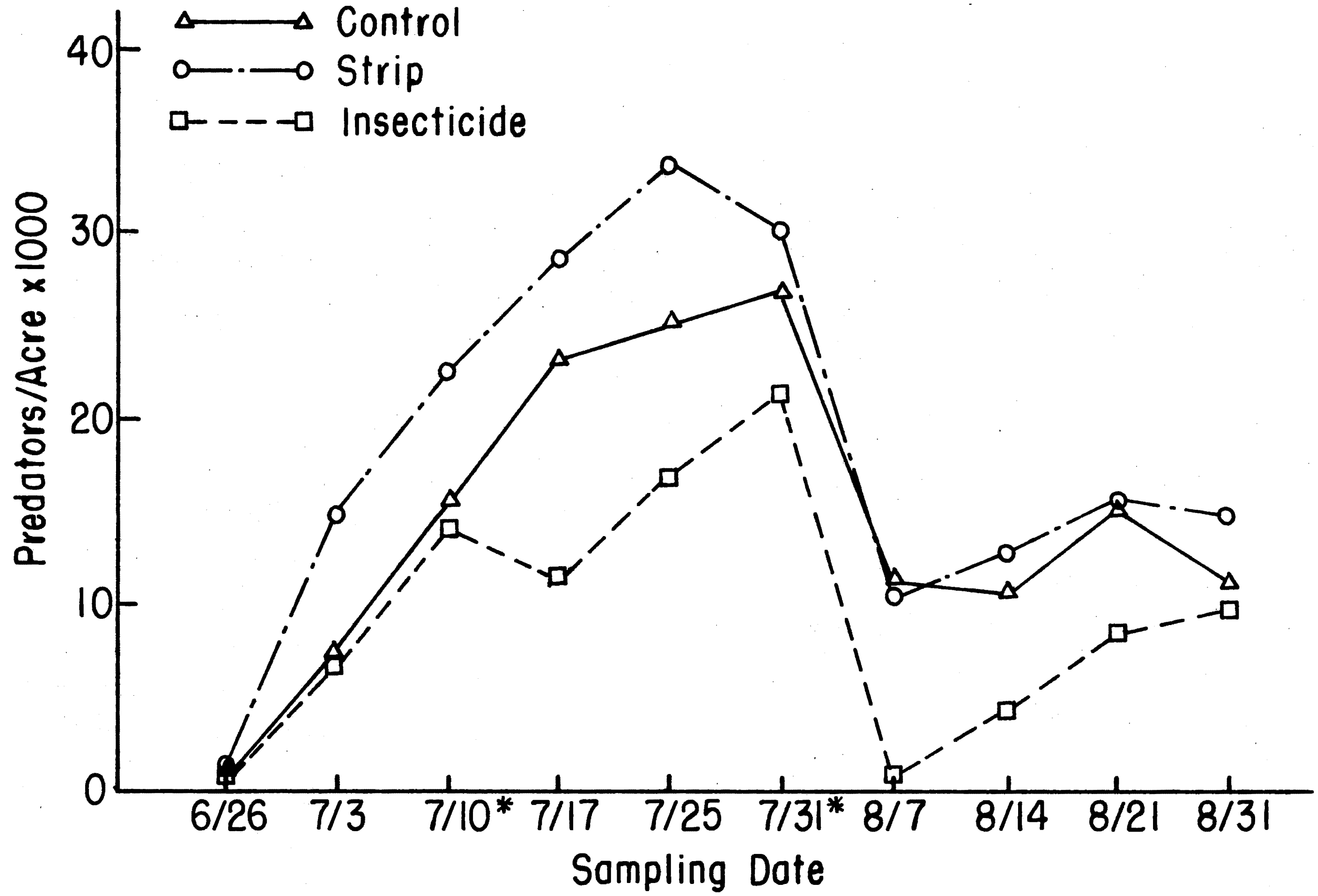

Figure 6. Average Numbers of Predators Per Acre, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

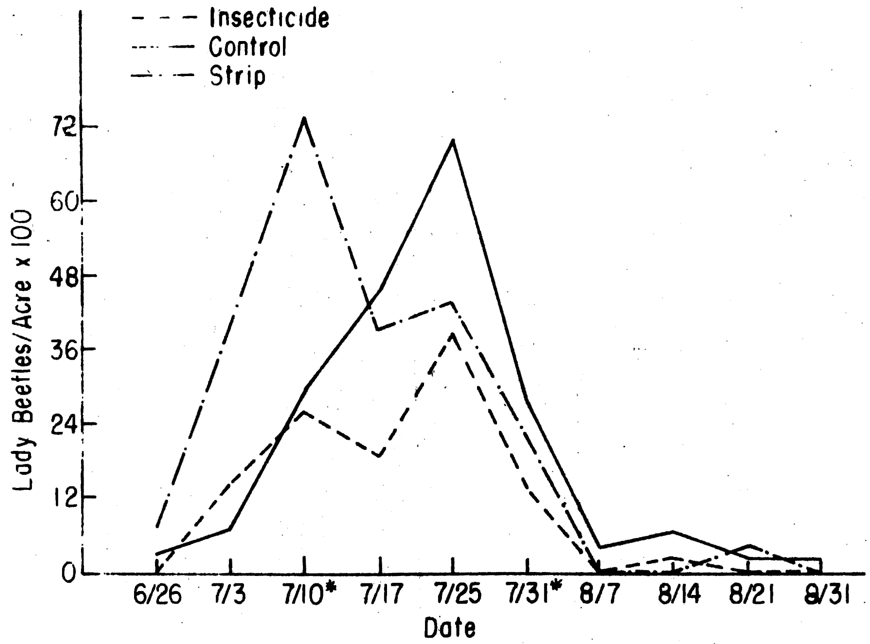

Figure 7. Average Numbers of Lady Beetles Per Acre, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

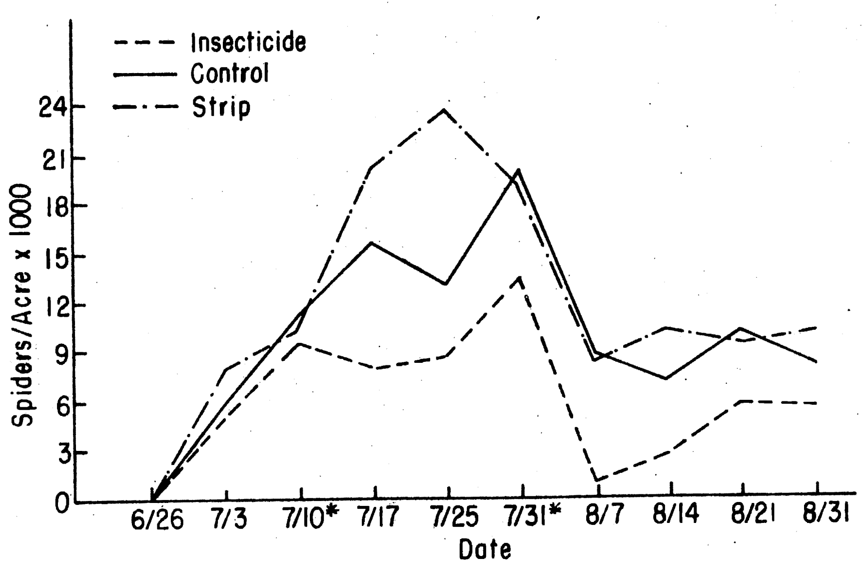

Figure 8. Average Numbers of Spiders Per Acre, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

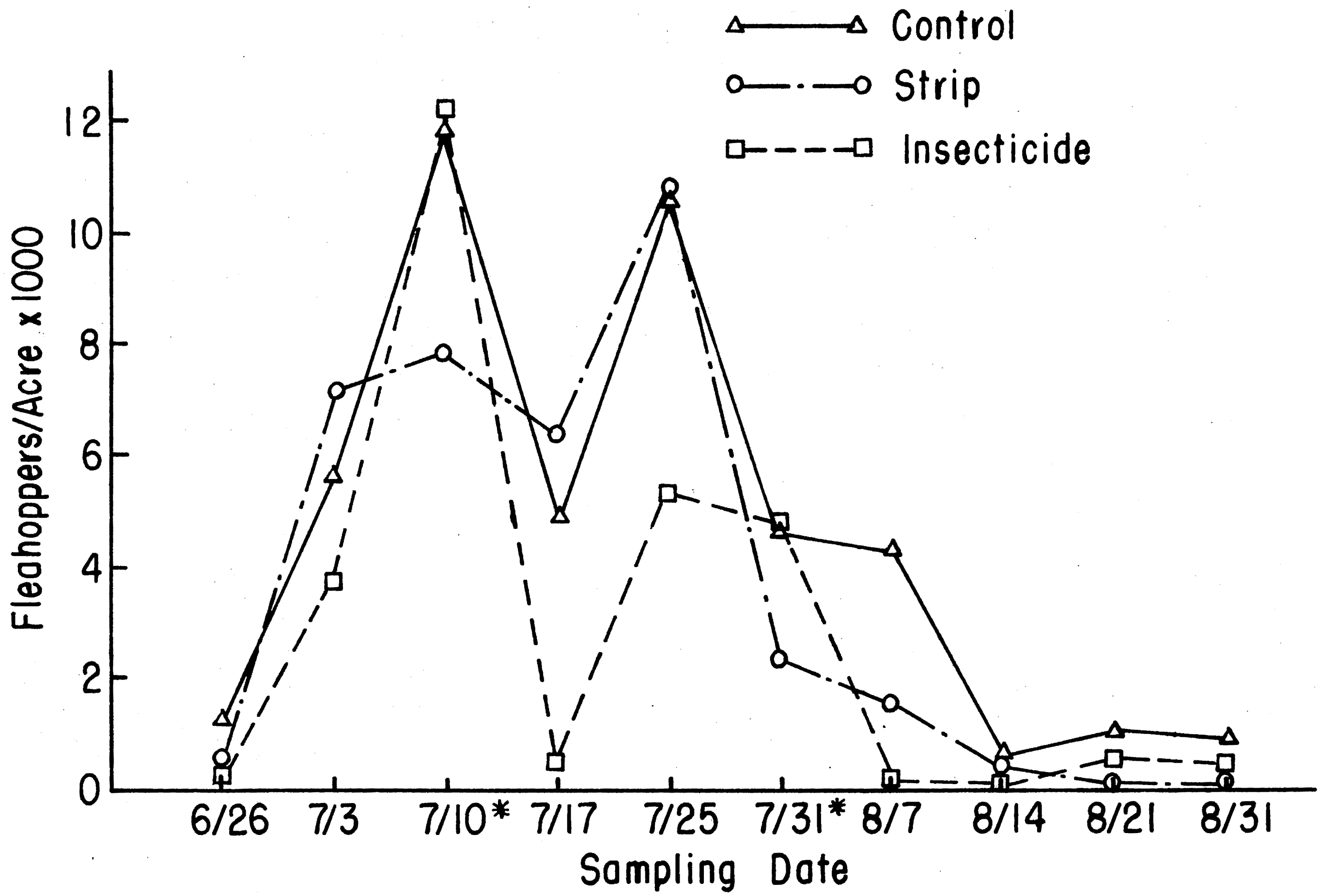

Figure 9. Average Numbers of Cotton Fleahoppers Per Acre, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

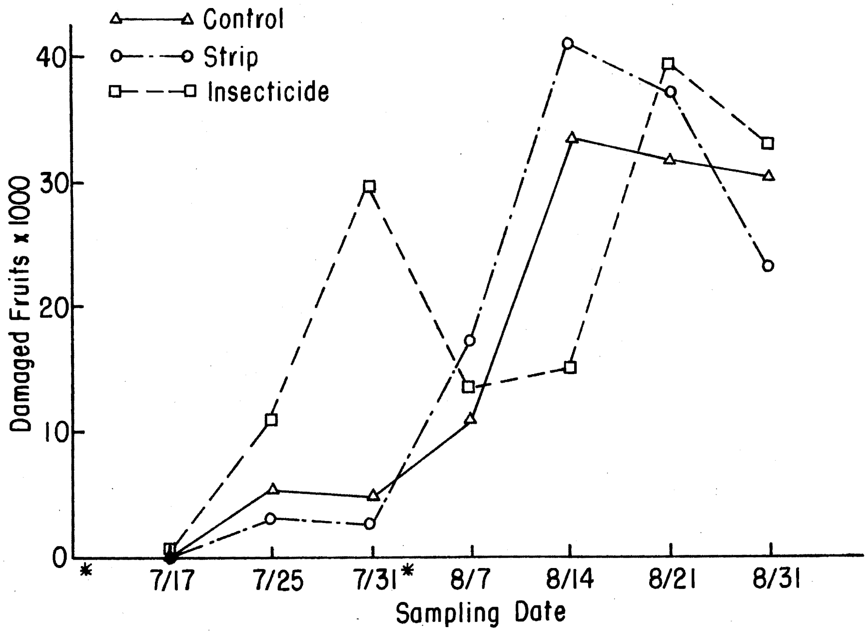

Figure 10. Average Numbers of Heliothis-Damaged Fruits Per Acre, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

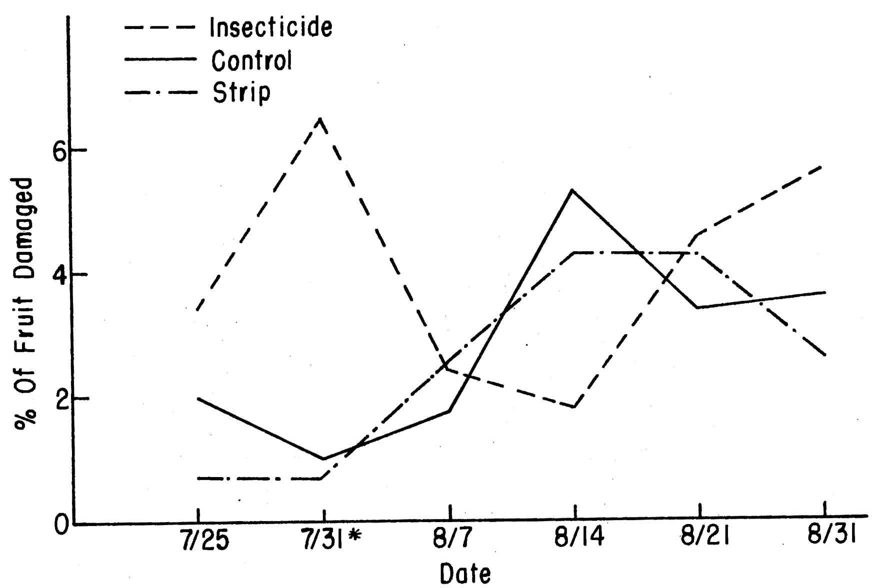

Figure 11. Average Per Cent of Total Fruit Damaged by Heliothis spp., Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

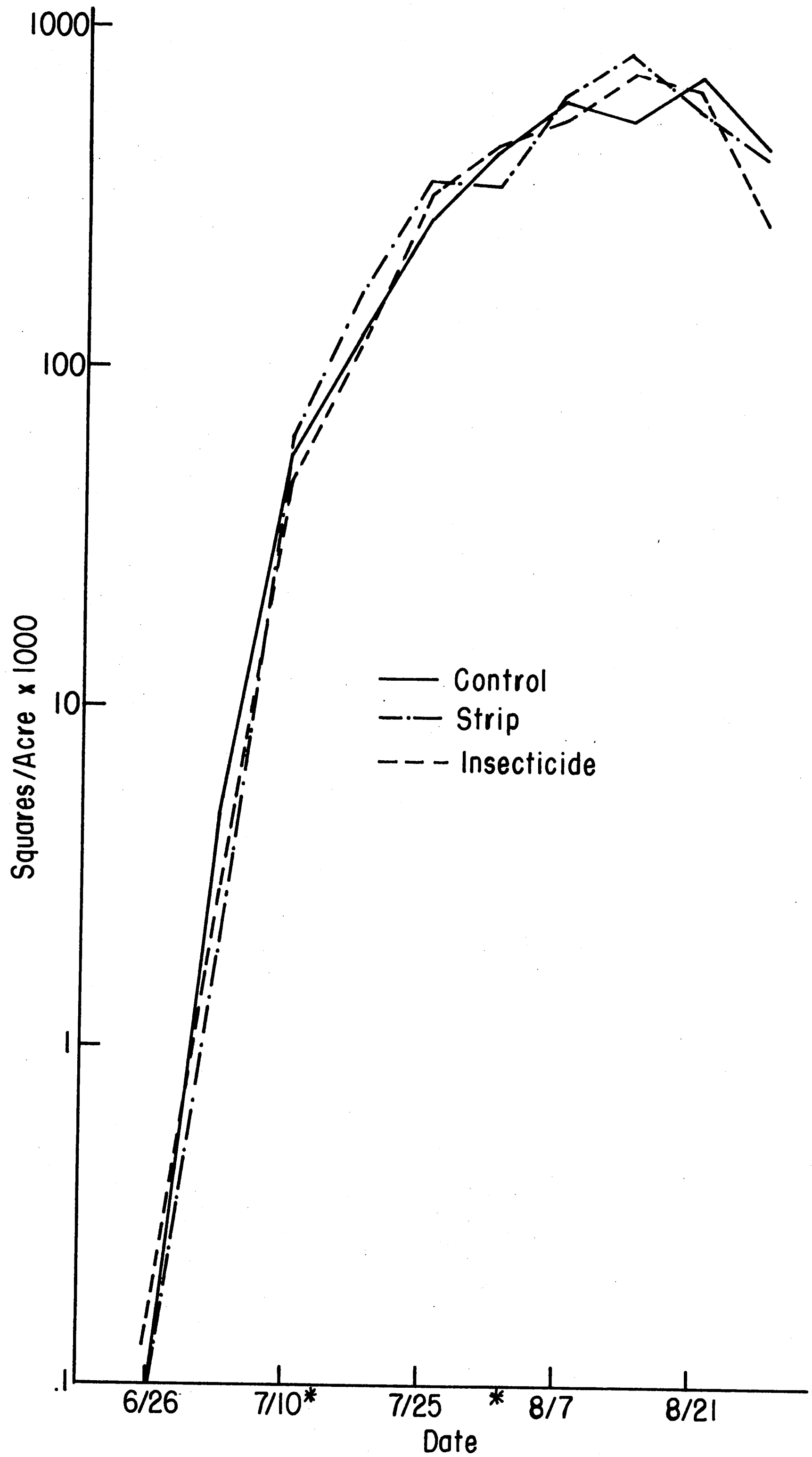

Figure 12. Average Numbers of Squares Per Acre, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

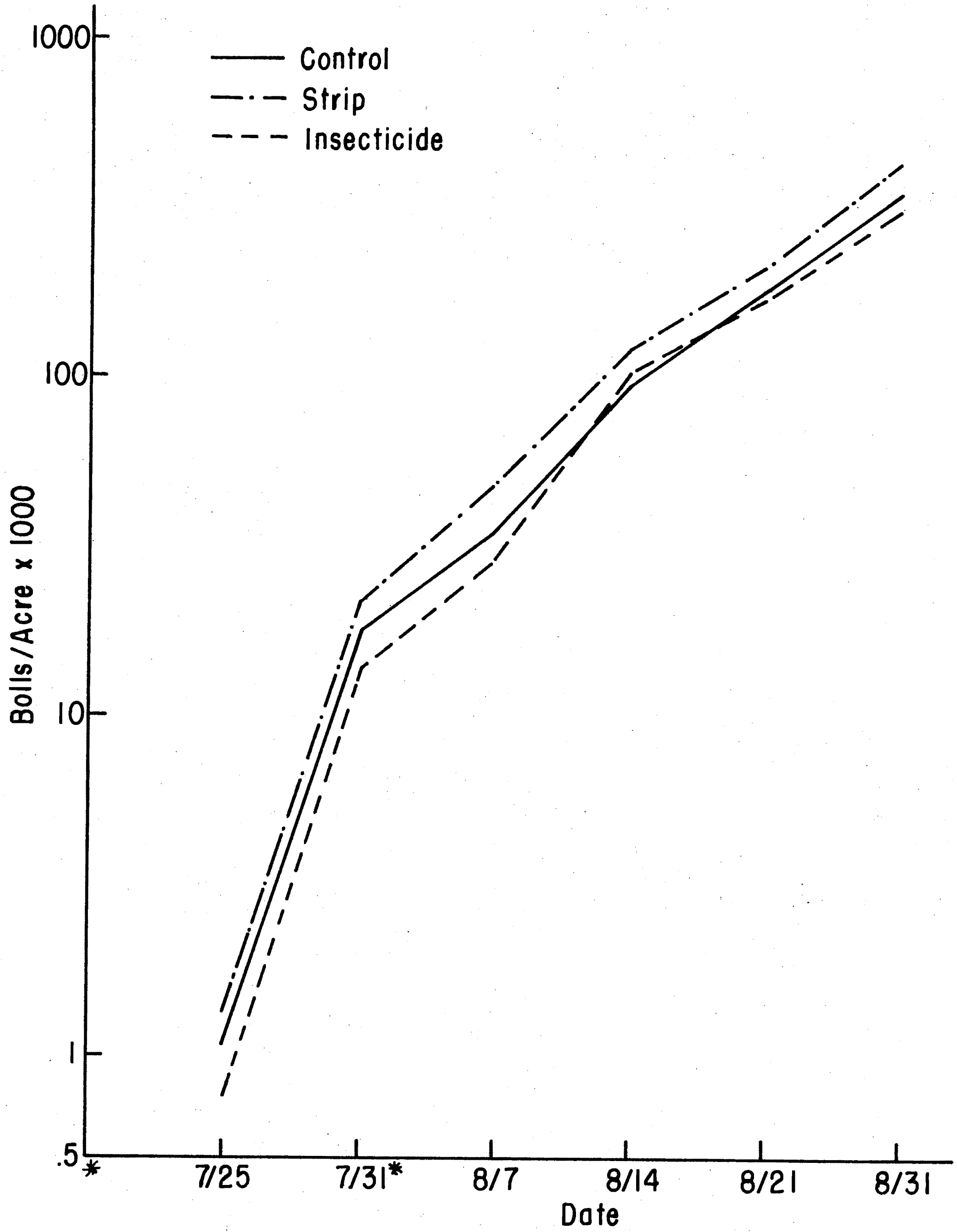

Figure 13. Average Numbers of Bolls Per Acre, Westburn 70 Cotton, Altus, Oklahoma, 1973 (*Insecticide application)

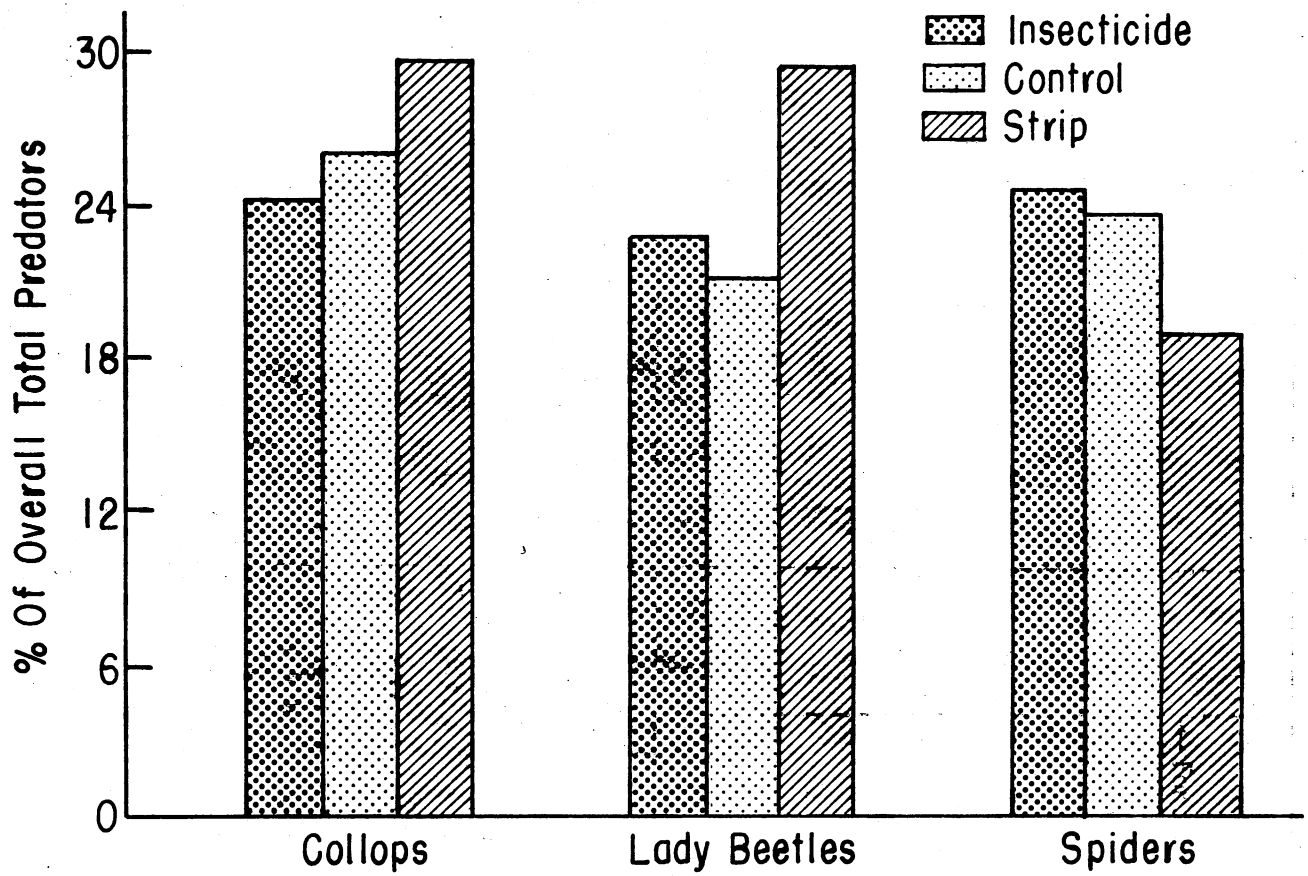

Figure 14. Percentages of Overall Total Predators Composed of Collops, Lady Beetles and Spiders, Thorpe Cotton, Tipton, Oklahoma, 1974

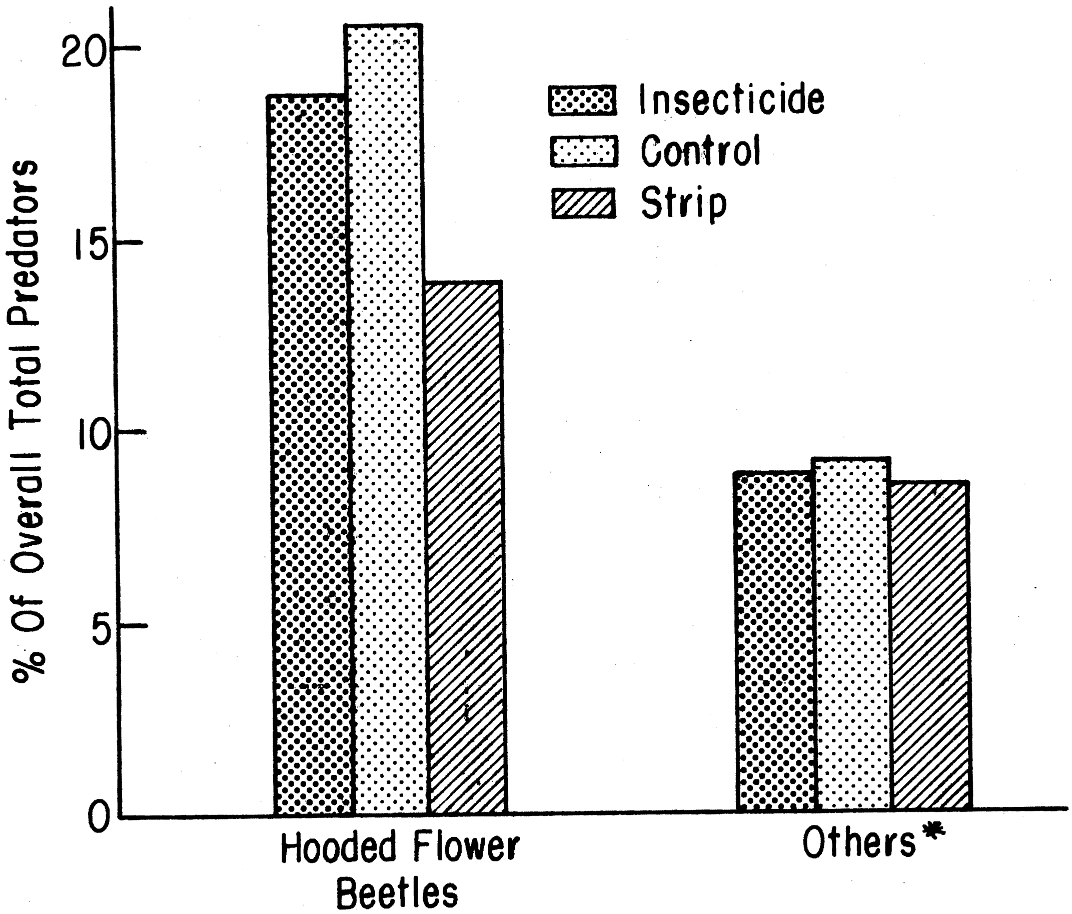

Figure 15. Percentages of Overall Total Predators Composed of Hooded Flower Beetles and Other Less Abundant Predators, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Big-eyed Bugs, Green Lacewings, Nabids)

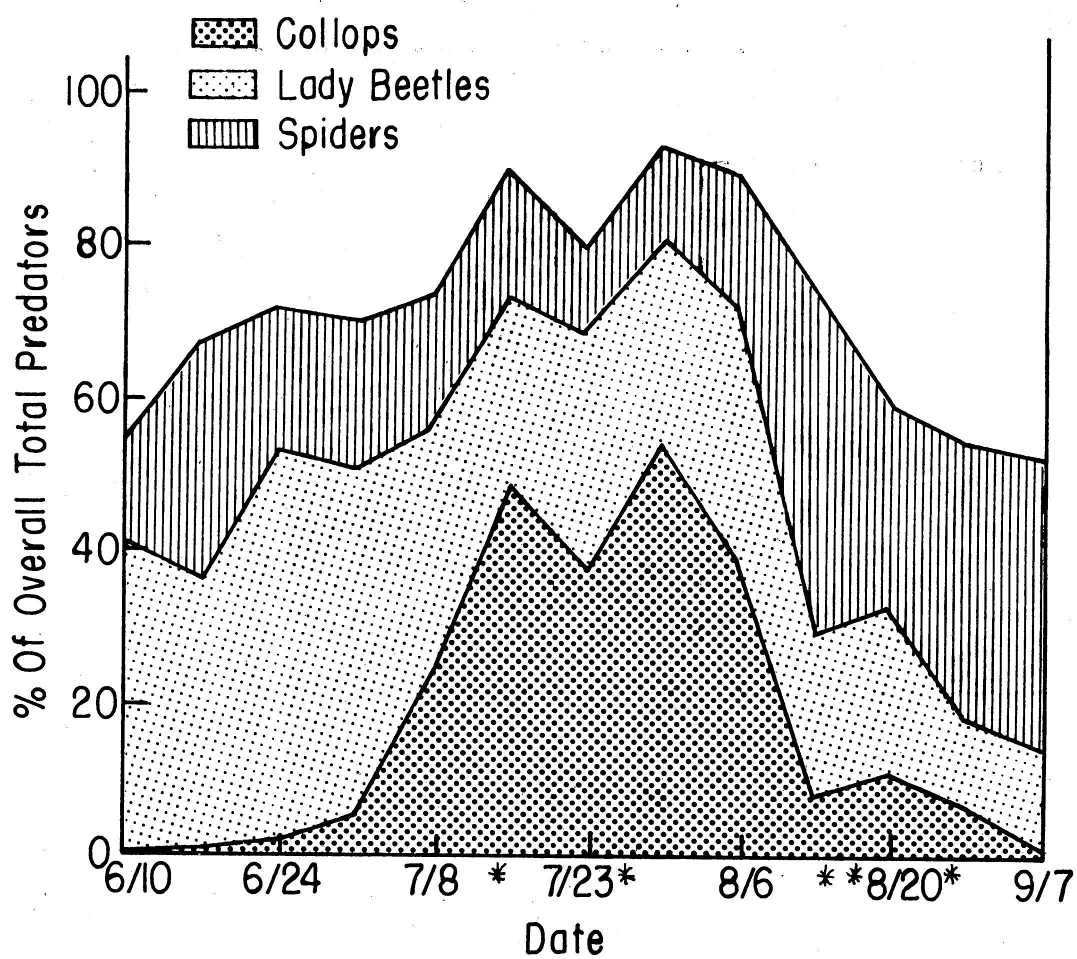

Figure 16. Relative Importance of Major Predators in Strip-Planted Scheme, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Insecticide application)

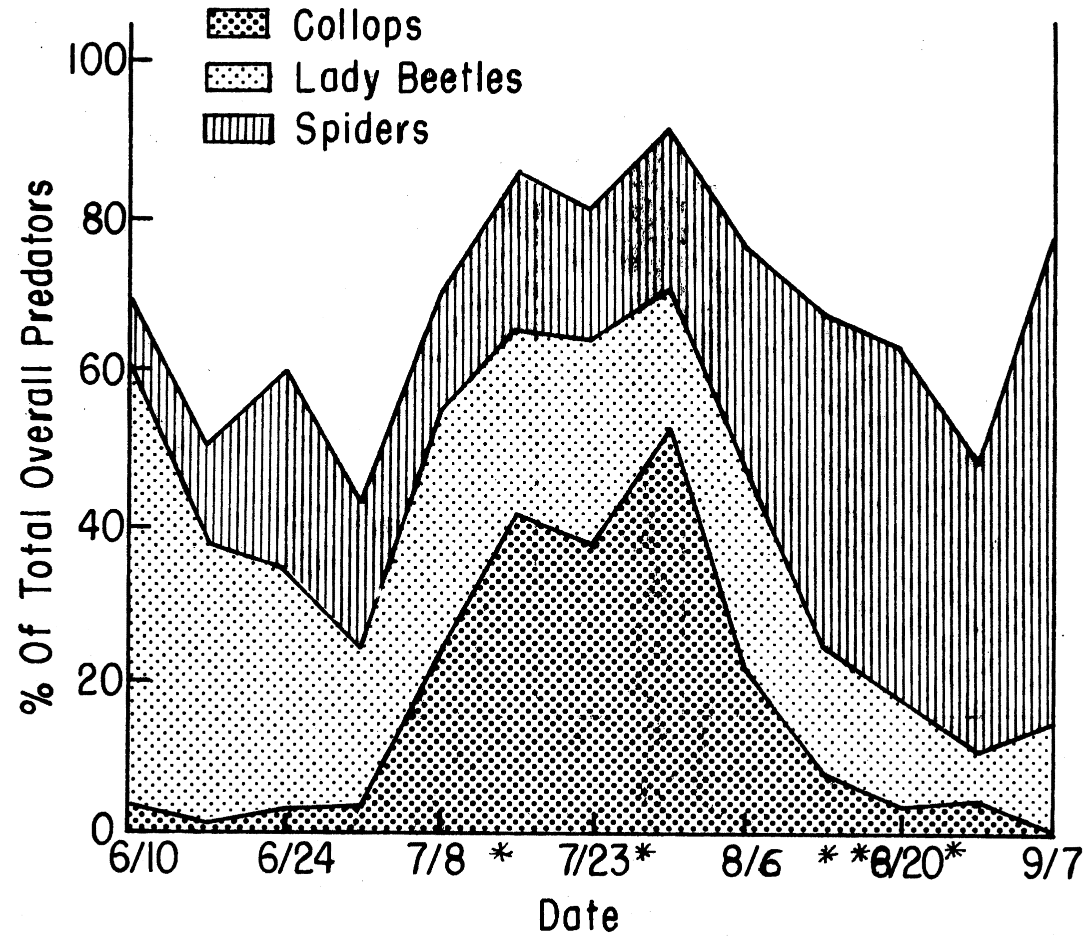

Figure 17. Relative Importance of Major Predators in Insecticide Scheme, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Insecticide application)

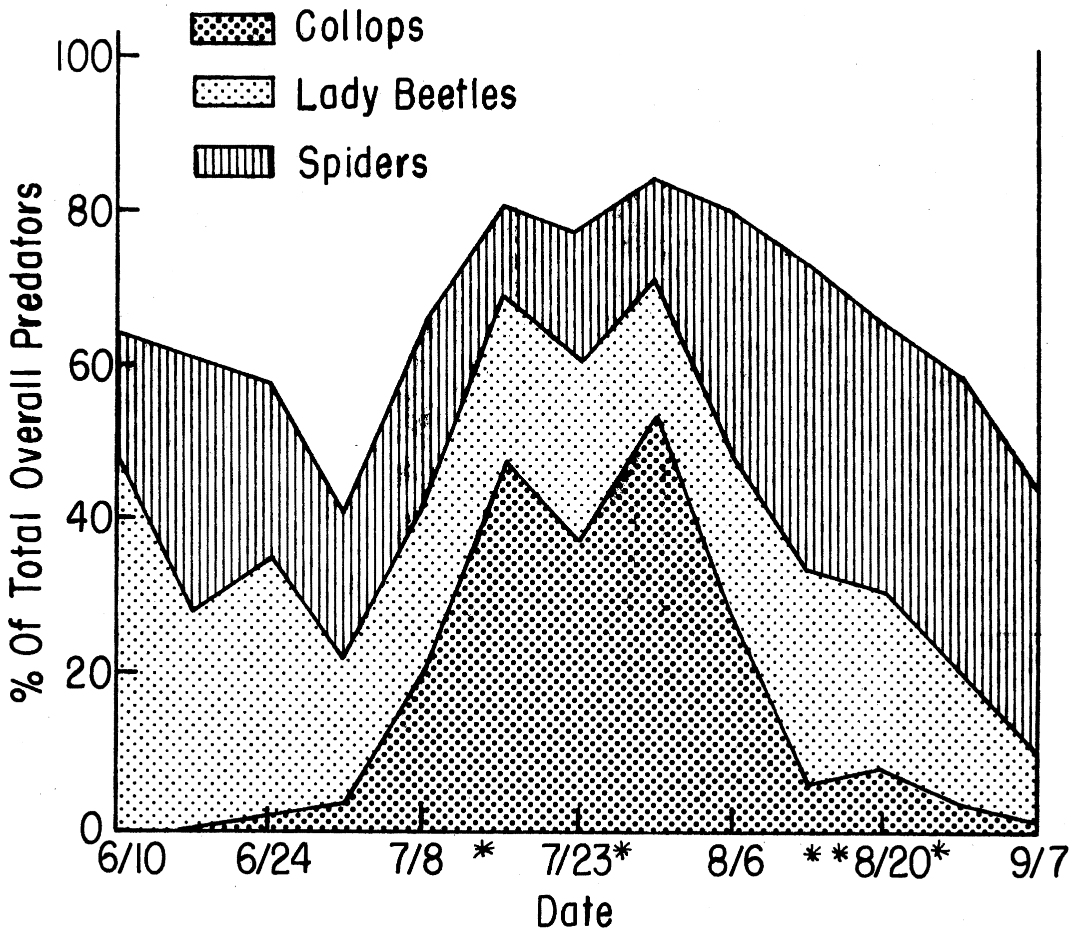

Figure 18. Relative Importance of Major Predators in Control Scheme, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Insecticide application)

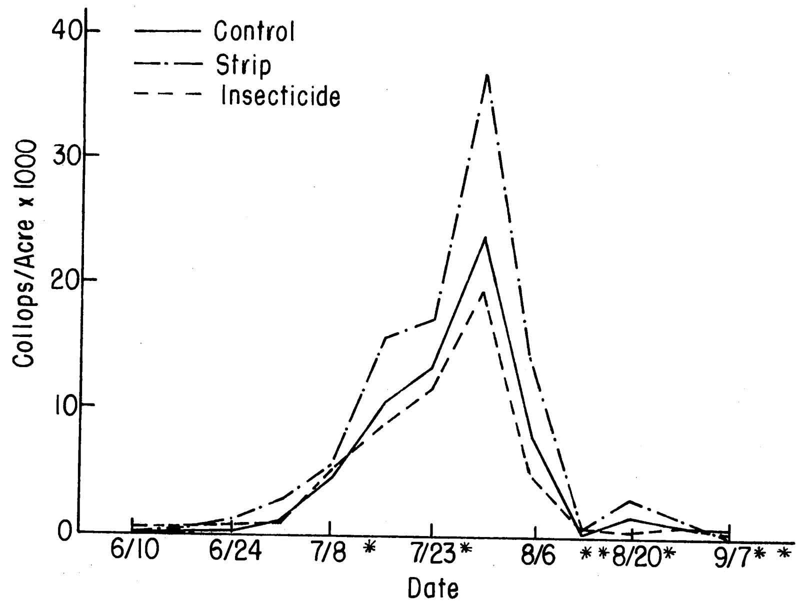

Figure 19. Average Numbers of Collops Per Acre, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Insecticide application)

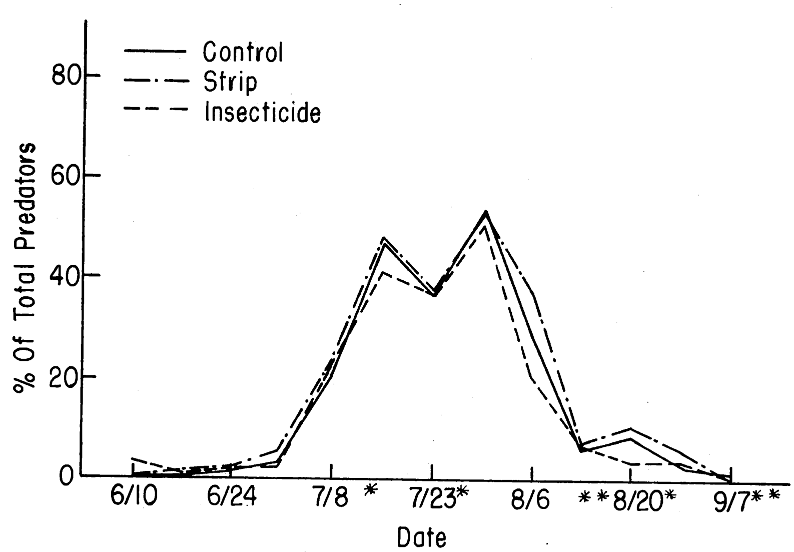

Figure 20. Per Cent of Total Predators Composed of Collops, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Insecticide application)

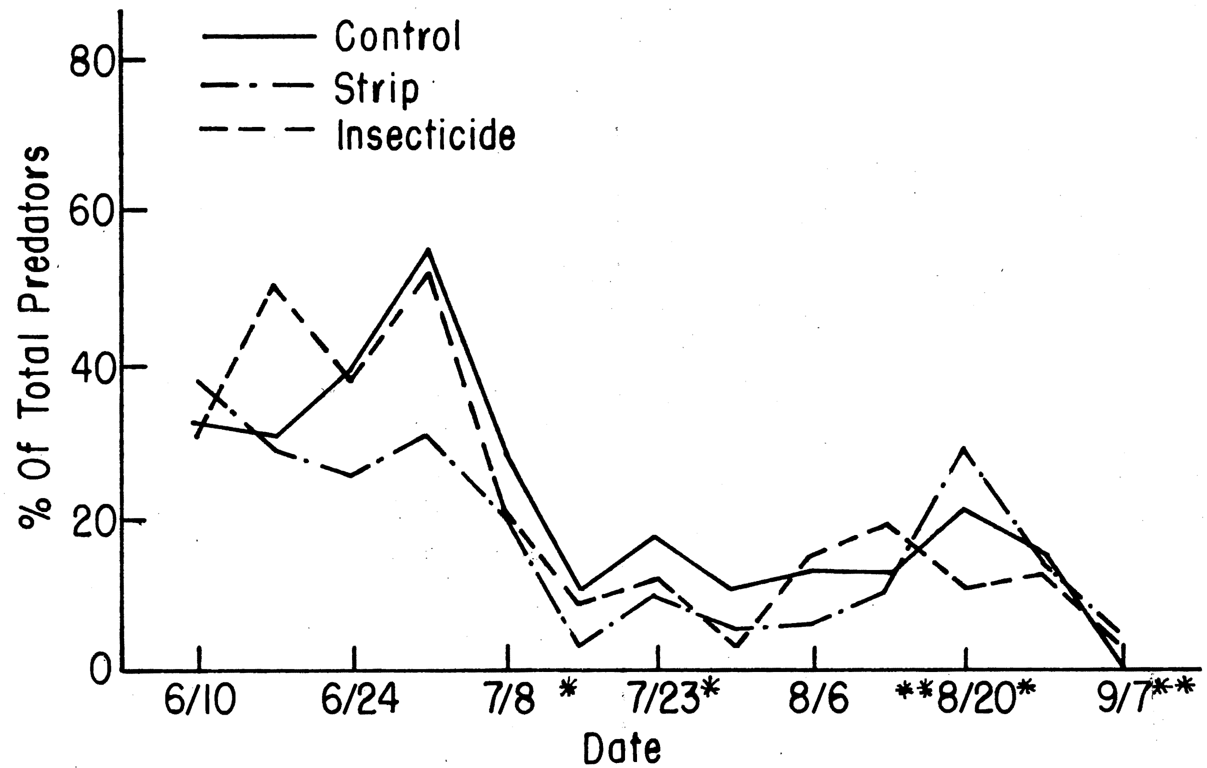

Figure 21. Per Cent of Total Predators Composed of Hooded Flower Beetles, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Insecticide application)

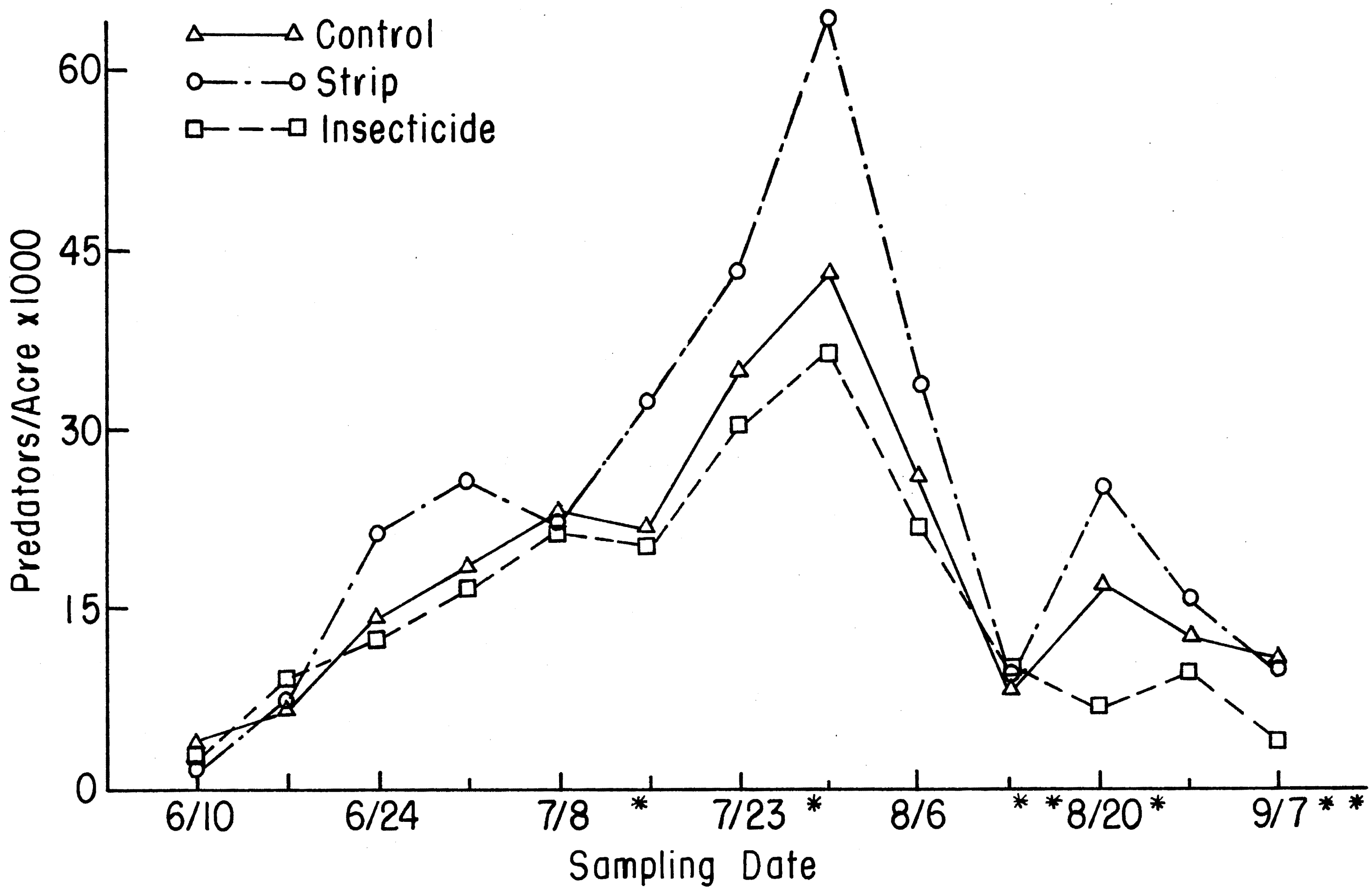

Figure 22. Average Numbers of Predators Per Acre, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Insecticide application)

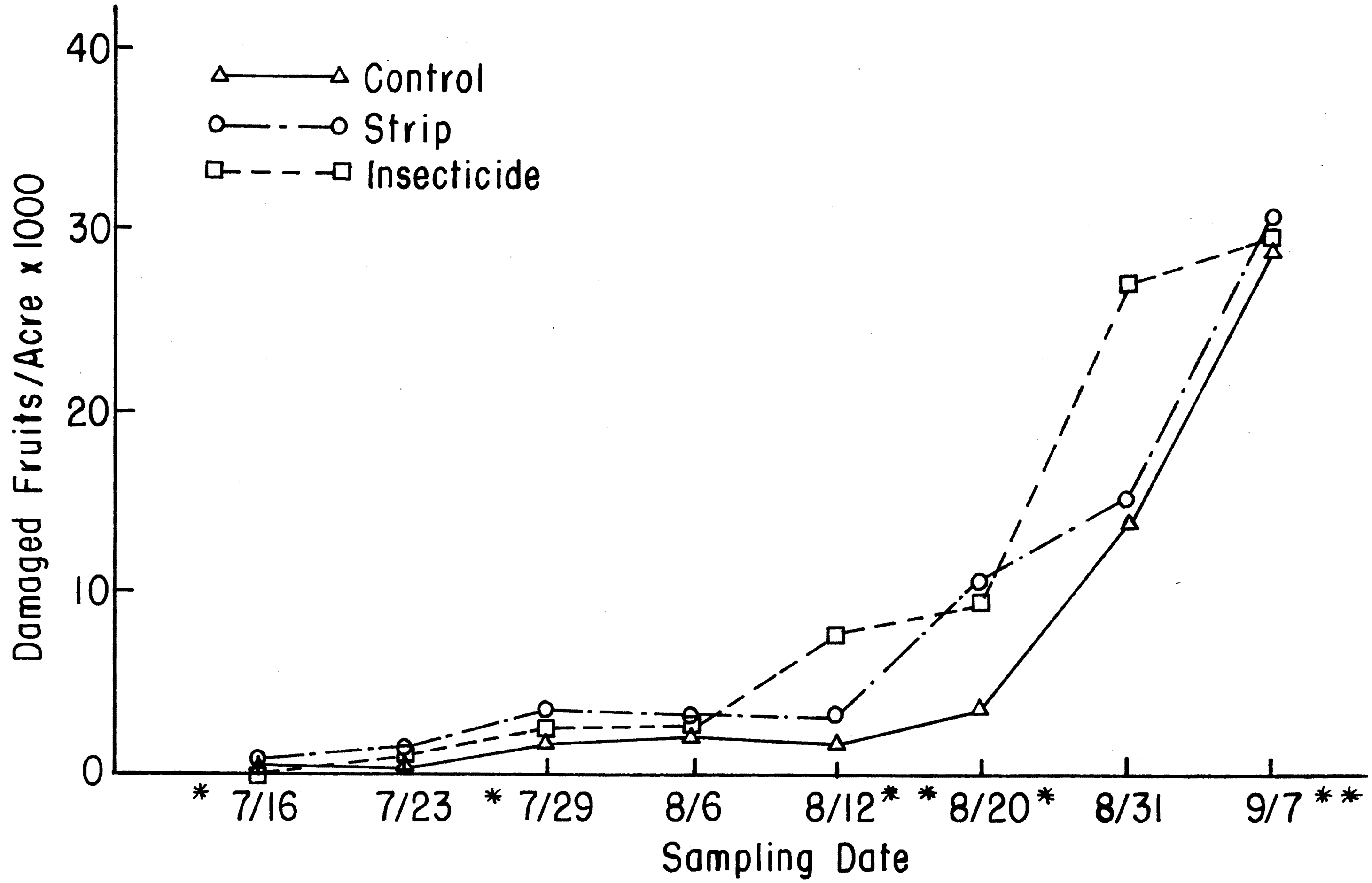

Figure 23. Average Numbers of Boll Weevil-Damaged Fruits Per Acre, Thorpe Cotton, Tipton, Oklahoma, 1974 (*Insecticide application)

VITA

Ethyl Kay Ensey Johnson

Candidate for the Degree of

Doctor of Philosophy

Thesis: COMPARISON OF THREE INSECT CONTROL SCHEMES ON POPULATIONS OF COTTON INSECTS AND SPIDERS, FRUITING CHARACTERISTICS, FRUIT DAMAGE AND YIELD OF COTTON

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